SECTION IV

MANUAL NO. 993-045925-001

TECHNICAL SERVICE INFORMATION for

MEMORYMOOG

MODEL 345

CAUTION

These servicing instructions are for use by qualified personnel only. To avoid risk of electric shock, do not perform any servicing other than that described in the Owner's Manual unless you are qualified to do so. Refer all servicing to qualified service personnel.

MOOG MUSIC INC.
2500 Walden Avenue, Buffalo, New York 14225

MOOG MUSIC
p/a Waalhaven Zuid Zijde 48, 3088 HJ, Rotterdam, The Netherlands

Dear Fellow Synthesist:

Since you have proceeded this far in your reading, you have already demonstrated a keen interest in at least four endeavors: music, electronics, computers and, of course, SYNTHESIS. This manual can provide you with added depth in this multi-faceted knowledge and improve your long-term synthesizer musicianship.

This is a preliminary service manual which will be available in final form during the first quarter of 1983, so if you or your service engineer have comments concerning the format or content, let us hear from you. Direct your suggestions or corrections to the attention of the Moog Service Department.

Have this manual handy along with the schematics (blueprints) included in the owner's packet, in the event your MEMORYMOOG requires service. Be sure to check the Modification section before proceeding with field repair or calibration & have your unit serviced at the nearest authorized Moog service center as shown on the list included in your owner's packet.

Read on!

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MEMORYMOOG OWNER'S MANUAL ADDENDA

Pg. 6 - Under Section 1.9 (Arpeggiator), the following modes should be added:

7) Plays all notes simultaneously

8) Plays back notes in order they are played, first-to-last

9) Plays back notes in order they are played, first-to-last (latched)

Ppg. 40, 41, 42 - The line drawings show connections being made to the side of the 1120 Footpedal Controller. The connections should be made to the front of the Controller, as shown in the photograph on Page 48.

Pg. 46 - The diagram labelled "Contoured Oscillator 3 Modulation" suggests that the Oscillator 3 amount control is used for contoured voice modulation. This is incorrect; for contoured voice modulation, turn up the Filter Contour pot (be sure the CONTOURED OSC 3 AMT switch is on).

VENTILATION CLEARANCE - The Memorymoog has a built-in cooling fan that exhausts hot air from the instrument. For optimum tuning stability, be sure that this fan is not obstructed in any way; i.e., do not operate the Memorymoog if it is sitting on deep-pile shag carpeting. Also, always make sure that the instrument is firmly seated on all four "feet"; if it rests on a board or surface that is too narrow, the board or surface may be flush against the fan outlet and heat may not be able to escape the instrument, resulting in tuning instability.

November 30, 1982

MEMORYMOOG SERVICE MANUAL

TABLE OF CONTENTS

SPECIAL NOTE:

* Indicates Input and/or Output is Active Low (BAR)

MEMORYMOOG SPECIFICATIONS AND FUNCTIONS

The Memorymoog is a versatile six-voice, programmable polyphonic synthesizer with the classic Moog sound, housed in an anodized aluminum cabinet trimmed with selected walnut.

All Memorymoog functions are under the control of a Z-80 micro-computer which continually monitors the soundpath, responding to all performer input through the keyboard, panel controls, foot pedals and system controller.

The front-panel settings are stored as a "program". The Memorymoog will remember 100 programs. These are stored and recalled by the system controller, which is used to access all special functions of the Memorymoog. In addition, 20 program chains - sets of 10 programs - can be stored and stepped through forward or back with footswitches for fast onstage voice changes.

Two programmable foot pedal inputs provide control of volume, pitch, filter cutoff frequency, modulation amount and sync sweep, allowing the performer to keep both hands on the keyboard. The routing and settings of these pedals are programmable.

Different keyboard modes may be selected through the system controller. The modes are: 1. CYCLIC - the first key played is sounded by voice A, the second key, voice B, etc. 2. CYCLIC WITH MEMORY: similar to #1 except that a repeated key will not be reassigned. 3. RESET: any single key will be assigned to voice A (this mode will behave like a monophonic keyboard on individual lines). 4. RESET WITH MEMORY - similar to #3, but with memory function described in #2.

In monophonic performance, the number of active voices (one to six) may be selected to be played in unison. The keyboard priority (low-note, high-note, or last-note-played) may also be selected.

Glide may be activated in either the monophonic or polyphonic modes of operation.

The Memorymoog operates in a continuous edit state; setting of any control may be instantly changed by moving that control.

When editing, the alphanumeric display shows both the memorized value of the control and the edited value.

All information stored in the Memorymoog may be saved on a standard cassette for later re-use.

KEYBOARD
C-C, 61 keys (5 octaves)

VOICES
The Memorymoog is a 6-voice instrument. Each voice contains:

OSCILLATORS
3 Audio oscillators - range: 16', 8', 4', 2'. (Range is extended to 32' with transpose switch in performance area).
Waveforms available: variable pulse, sawtooth and triangular.
Oscillators 2 & 3 have dual concentric frequency pots; center knob for fine tune (12 turns), outer knob for coarse tune.
Sync Osc 2 to Osc 1.
Osc 3 acts as an audio or modulation oscillator. Osc 3 rate: .2 Hz to 8 KHz.

VOICE MODULATION
Osc 3 signal or filter contour may be routed to Osc 1, 2, pulse width 1, 2 and/or filter. Filter contour can control amount of Osc 3 modulation effect.

MIXER
Individual level controls for each oscillator and digital pink noise source.

MODULATION
LFO frequency - .1 Hz to 100 Hz.
Waveforms available: triangle, reverse sawtooth, sawtooth, square or sample & hold. Routing to Osc 1, 2, 3, pulse width 1, 2, 3 and/or filter.

VOLTAGE CONTROLLED FILTER
Moog 24 dB/octave filter. Filter keyboard tracking selectable 1/3, 2/3 or full.

CONTOUR GENERATORS
Two four-part (Attack, Decay, Sustain, Release) contour generators. Attack time: 10 seceonds maximum.
Decay & Release time: 20 seconds maximum.
Return-to-zero, unconditional contour and keyboard follow modes are selectable for the contours.

FOOTPEDALS
Two Moog 1120 footpedals can be connected. Pedal 1 controls pitch, volume & filter. Pedal 2 controls mod amount & Osc 2 pitch. Pedal assignment and sensitivity are stored as part of a program.

GLIDE
Type: Linear
Active in all monophonic and polyphonic modes. Glide modes are dependent on keyboard assignment modes.

SYSTEM CONTROLLER CODES

C0 - Sequentially flashing LED's - a service routine
C1 - Cassette Save
C2 - Cassette Load
C3 - Cassette Verify
C4 - Defeats voices sequentially - a service routine
C5 - Frequency center for Osc 2 & 3 to Osc 1 (zero beats)
C6 - Tuning Calibration - defeats auto tune
C7 - Auto assigned tuning (for servicing)
C8 - Program enable and disable
C9 - live front panel (programming)
D0 - through D9 are program sequence codes
A - advance program chain
B - back step program chain

OUTPUTS

Programmable volume for program level balancing. Master output volume control. Headphone output level.

REAR PANEL

Balanced line (600 ohms) & high level (unbalanced 5K) outputs.
Footpedal in 1 & 2.
External synthesizer CV, gate and S-trig outputs (with range & scale trims).
Release, Hold, Program Advance and Program Back Step footswitch inputs.
External Clock input (to arpeggiator).
Cassette Interface.

POWER REQUIREMENTS

Domestic: 120-127 volts 50/60 Hz
Export: 200-254 volts 50/60 Hz

POWER CONSUMPTION

110 watts

DIMENSIONS & WEIGHT

Net weight: 38 lbs. (17Kg)
Overall size: 40" by 18-3/8" by 6-1/2"
101.6 cm by 46.7 cm by 16.5 cm

GENERAL

The MEMORYMOOG is a state-of-the-art six voice programmable synthesizer with a five octave keyboard designed in the tradition of the MINIMOOG.

SOUND

The design of the MEMORYMOOG is very similar to the MINI with three oscillators, two contour generators, MOOG 24db per octave filter and a voltage controlled amplifier. In addition, it includes other features to further improve the sound generation possibilities.

To the oscillators is added sync and variable pulse width. The contour generators were expanded to four parts with three modes of operation, including a mode where the attack, decay and release times track the keyboard for better simulation of acoustical instruments like the piano.

The voice card is further enhanced by two powerful modulation systems: LFO modulation and Voice modulation. The LFO modulator contains its own wide range oscillator and routing switches. The amount of modulation is controlled by the modulation wheel, a foot pedal or a fixed amount may be programmed. This modulation section controls all voices simultaneously and can be used to control pitch, pulse width or filter cutoff for vibrato and tremolo.

Voice modulation works on each individual voice card. The modulation signal for each voice comes from its own oscillator three and/or the filter contour. This generates independent modulation for each voice card. Voice modulation can also control pitch, pulse width and filter cutoff for chorus effects, sync sweeps and other musical effects.

PERFORMANCE ORIENTATION

Programming is made easier by first making almost everything programmable except for tune, final volume and headphone volume. Secondly, a full complement of knobs and switches have LED indicators. These first two features allow set-up of your personal programs just like a non-programmable monophonic synthesizer. Next, there are 64 locations where these programs can be stored. If 64 is not enough, included is a cassette interface so programs can be stored on an inexpensive audio cassette deck providing almost unlimited storage.

In addition to the above, a two-digit display tells what program is currently in use while a second eight-character alphanumeric display keeps the player informed of the instrument status. For example, it tells when the instrument is ready to play (after a short warm-up), when the autotune cycle is complete or when a loaded cassette is verified.

For program selection, one need only punch in a two-digit number on a keypad. This gives simple, reliable and fast program selection.

The MEMORYMOOG has 20 program sequence registers. In these registers one can load up to ten program numbers in any order and during performance sequence the programs with a foot switch. Lastly are programmable inputs for voltage foot pedals like the MOOG 1120. These foot pedals allow control of pitch, volume, modulation amount and filter cutoff.

ARPEGGIATOR

Unlike conventional arpeggiators that are limited to playing notes up and/or down the keyboard, the arpeggiator in the MEMORYMOOG is more like a micro sequencer in that it arpeggiates notes in the order depressed. The arpeggiator will then play them forward or forward and backward. This gives a variety of musical patterns limited only by imagination. The notes can be "latched" so the arpeggio will continue to play after key release. Notes in the pattern can be replaced in real time by adding new notes from the keyboard. The arpeggio can also be transposed from the keyboard over a five octave range.

The arpeggiation rate is set by the LFO modulation oscillator and is therefore programmable. In addition, the modulation oscillator is reset when the first note on the keyboard is played to keep the arpeggiator in sync with the music.

The internal clock is supplemented by an external clock input for syncing the arpeggiator with an external device. The internal clock works fine for most applications until playing an arpeggio against something like a rhythm box. Then a problem arises because both have independent clocks. Even with careful adjustment of one against the other, a small error will still exist that will cause the two to slowly drift apart destroying timing. The external clock input gets around this problem since the clock output of the rhythm box drives the arpeggiator. The two systems then will work off the same time base and, therefore, remain in sync.

CIRCUITRY

The MEMORYMOOG is a six voice fully programmable synthesizer in which all voicing parameters are processed and stored digitally. Interface with the synthesizer circuitry (VOICE CARDS) is accomplished with digital to analog conversion of this data and transmission to the appropriate circuit element via control inputs from the front and rear panel switches, potentiometers and keyboard. These functions are controlled by a Z80 microprocessor or CPU on the DIGITAL board in response to program information stored in the system ROM. Refer to the accompanying block diagram.

All continuously variable functions are voltage controlled and all switching functions are accomplished with electronic switching. Data for control of continuously variable functions is processed and stored in the system RAM in digital form, converted to analog information by the D/A converter resulting in serial current control data which is multiplexed for conversion to control voltages on the demultiplexer (DMUX) board. All switching inputs are either TTL compatable or are level translated to interface directly with the DIGITAL board.

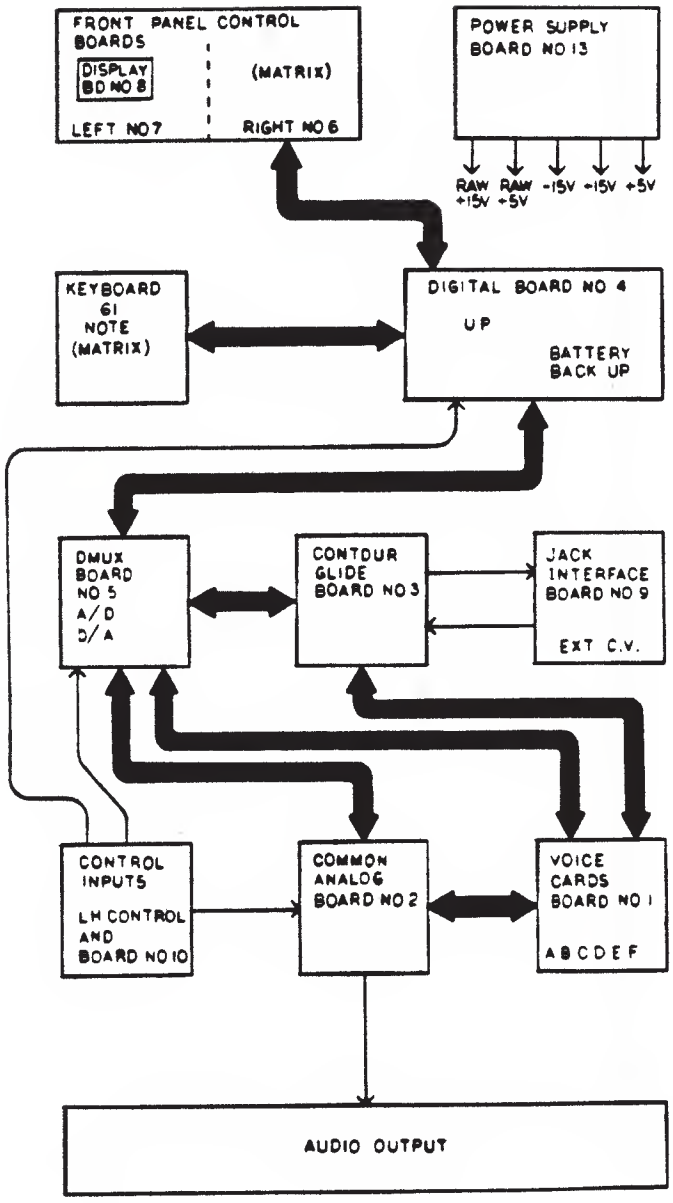
The DMUX board provides triggers for the CONTOUR/GLIDE board, 18 output drives for the COMMON ANALOG board which are then bussed to the VOICE CARDS, and in addition, decodes front panel analog potentiometer settings into digital information using software generated successive approximations.

The CONTOUR/GLIDE board generates polyphonic and monophonic glide, a loudness contour and two filter contours.

Particularly note that in the MEMORYMOOG, certain circuit elements are CRITICAL to the performance and operation of the circuit and should be checked for calibration and operation before ANY other adjustment or repair is attempted. In order of priority, here is a list of parameters to be checked and adjusted only if required:

1. The +15V, -15V & +5V power supplies on the POWER SUPPLY board are measured on DMUX board. (See power supply section).

2. The +10V DAC reference supply (DAC ZERO and FULL SCALE) on the DMUX board.



BLOCK DIAGRAM

POWER SUPPLY

The power supply includes a printed circuit board assembly, fan, heat sink, split primary transformer and a bottom mounted plate that converts 100/120 to 220/240 Volts. The plates include a connector and all the appropriate fuses including secondary fuses. Regulation is accomplished with 723 regulators, MPSU05 drivers and a series of TIP41 pass transistors. There is a raw 5V tap which feeds the FRONT PANEL LEDs and a tap of the +15V supply for the power shutdown circuit on the DIGITAL board. The power supply has remote sense lines which are wired to the DMUX board. Each of the three independent output windings of T1 is applied to a full wave bridge rectifier and regulator circuit to provide regulated -15, +15 and +5 VDC outputs. The output of each bridge rectifier is filtered by an electrolytic capacitor having a bleeder resistor connected in parallel to remove any residual charge when power is removed from the unit.

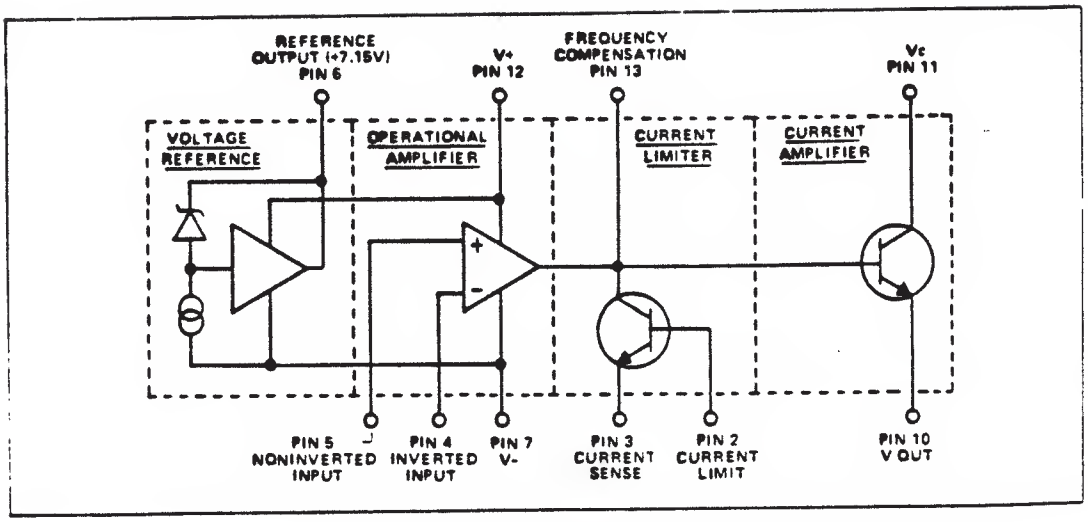
The heart of each regulator section is comprised of a 723 integrated circuit consisting of four basic sections: a temperature compensated voltage reference, operational amplifier, current limiter and current amplifier. The voltage reference section of the +15 and +5 VDC supplies produces a stable +7.15 +/- 0.36 VDC output at pin 6 which may be used at that level or divided down. The operational amplifier section is used as a linear amplifier to compare a direct or divided down reference voltage applied to pin 5 with a divided down sample of the power supply output voltage applied to pin 4. The current amplifier section amplifies the small current obtained from the output of the operational amplifier section and is used as an emitter follower to drive external transistors from pin 10. The current limiter section, when connected to external circuitry, acts to limit or reduce the current available to the current amplifier section should a power supply current overload occur.

The output from each bridge rectifier and filter is a considerably higher voltage than the regulated output voltage. Transistors Q1, Q3, Q5 and Q6 are emitter followers acting as electronically variable resistors controlled by the current applied to their bases. Transistors Q2, Q4 and Q7 operate as current amplifiers driving Q1, Q3, Q5 and Q6. The +7.15 VDC voltage reference from pin 6 of the 723 IC is applied to pin 5 (through a divider resistor on the +5 VDC supply) which is the noninverting input to the operational amplifier section of the IC. A voltage divider between the positive sensing terminal and the negative sensing terminal applies a voltage proportional to the output voltage into the inverting input (pin 4) of the operational amplifier to be compared with the reference voltage applied to pin 5. If the output voltage is too high, the voltage at pin 4 will be higher than the voltage at pin 5. This reduces the current into the base of the driver transistor in turn reducing the current into the base of the pass transistor causing the output voltage to drop to the correct level. If the output voltage is too low the opposite action occurs.

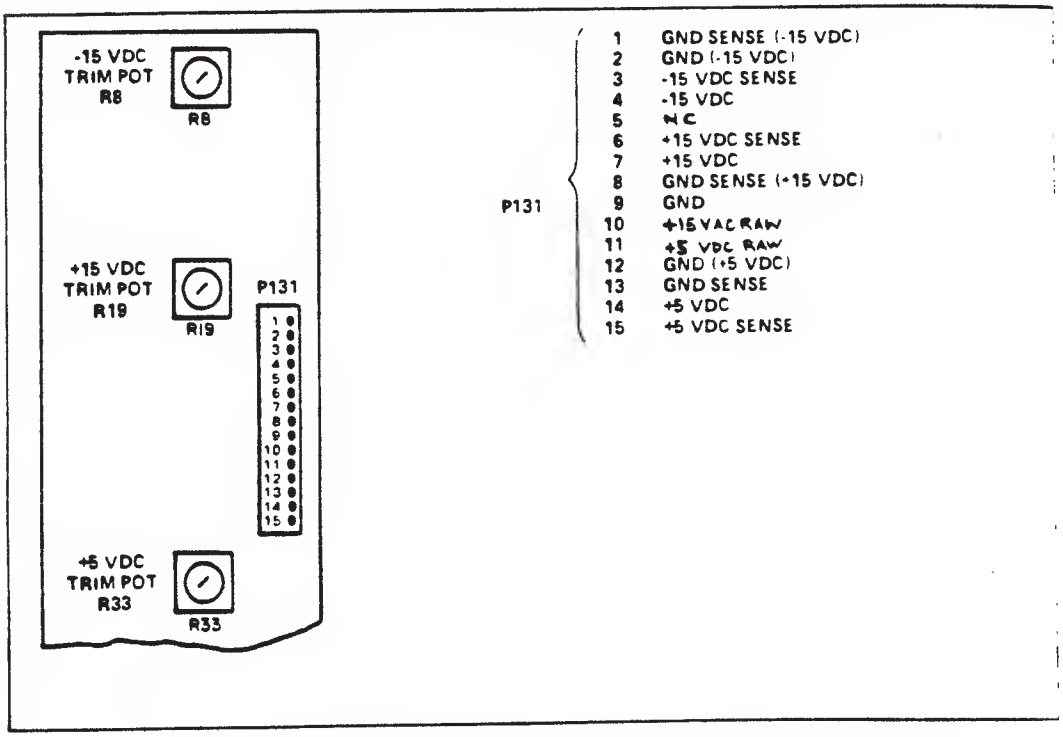
The two types of overcurrent protection provided include a constant current overload protection used on the + and -15 volt output. On the + and -15 volt outputs, resistors R6 and R17 are in series with the output. The current limit transistor in the 723 IC is connected to this resistor so that if the voltage drop of this resistor exceeds 0.6 volt due to excessive output current, this transistor conducts to prevent any further increase in the output current. When this point is reached, the output voltage will start to drop. The foldback overload protection used in the +5 volt section of the power supply operates by sensing both voltage and current. An overload is first sensed by the combined drop across the base-emitter junction of Q5 and the drop across R31. When the combined drop exceeds approximately 1.2 volts, the current limit transistor in the IC starts to conduct causing the output voltage to begin to drop. When this happens, the voltage drop across the divider becomes less causing the current limit to conduct even more. As a result of this regenerative action, the short circuited current of the power supply is much less than the rated full load current.

Variable resistors R8, R19 and R33 allow for individual adjustment of each output voltage. Resistors R10, R21 and R35 and diodes CR6 and CR13 prevent the outputs from rising to excessive levels should one of the sensing leads accidentally become disconnected. Diodes CR7, CR14 and CR20 across each output protect its output from accidental application of a reversed voltage to its output terminals. Capacitors C3, C6 and C9 provide a low dynamic impedance for each output.

Refer to the accompanying power supply diagrams and schematics.



VOLTAGE REGULATOR INTEGRATED CIRCUIT (723 DIP PACKAGE)



POWER SUPPLY ASSEMBLY ADJUSTMENT CONTROLS AND OUTPUTS

DIGITAL BOARD

The CPU is at the left center of the DIGITAL BOARD schematic along with three program EPROMs and room for four 2K x 8 RAMs of which three are used. These are CMOS battery backed-up RAMs. As each instruction is fetched from memory, it is placed in the instruction register and decoded. The control sections perform this function and then generate and supply all of the control signals necessary to READ or WRITE data from or to the registers, control the arithmetic logic unit and provide all required external control signals.

The Z80 CPU contains 208 bits of R/W (READ/WRITE) memory that are accessible to the programmer which is configured into eighteen 8 bit registers and four 16 bit registers. All Z80 registers are implemented using static RAM. The registers include two sets of six general purpose registers that may be used individually as 8 bit registers or in pairs as 16 bit registers. There are also two sets of accumulator and flag registers.

A PROGRAM COUNTER (PC) is a special purpose register that holds the 16 bit address of current instruction being fetched from memory. The PC is automatically incremented after its contents have been transferred to the address lines. When a program jump occurs the new value is automatically placed into PC, overriding the incrementer. The STACK POINTER (SP), another special purpose resistor, holds the 16 bit address of the current top of a stack located anywhere in external RAM memory. The external stack memory is organized as a last in first out (LIFO) file. Data can be pushed onto the stack from specific CPU registers or popped off the stack into specific CPU registers through the execution of PUSH and POP instructions. The data popped from the stack is always the last data pushed onto it. Two independent special purpose INDEX REGISTERS (IX & IY) hold a 16 bit base address that is used in indexed addressing modes. In this mode, an index register is used as a base point to a region in memory from which data is to be stored or retrieved. An additional byte is included in the instructions to specify a displacement from this base. The INTERRUPT PAGE ADDRESS REGISTER (I) is not used in the MEMORYMOOG and the MEMORY REFRESH REGISTER is also not used in the MEMORYMOOG.

The CPU includes two 8 bit ACCUMULATORS and associated 8 bit FLAG registers. The ACCUMULATOR holds the results of 8 bit arithmetic or logical operations while the FLAG register indicates specific conditions for 8 bit or 16 bit operations, such as indicating whether or not the result of an operation is equal to zero.

There are two matched sets of GENERAL PURPOSE REGISTERS, each set containing six 8 bit registers that may be used individually, as 8 bit registers or 16 bit register pairs. One set is called BC, DE, and HL while the complementary or alternate set is called BC', DE', and HL' and finally there is the ARITHMETIC LOGIC UNIT which has 8 bit ARITHMETIC and LOGICAL INSTRUCTIONS of the CPU which are executed in the ALU. Internally the ALU communicates with the registers and the external data bus and the internal bus.

Listed below are the Z80 CPU pin descriptions which are the functional designations for the pinout of the CPU. Refer to the accompanying figure for the corresponding pin number.

A0-A15 (address bus)
Tri-state output, active high. The address provides the address for memory (up to bytes), data exchanges and for I/O device data exchanges. I/O addressing uses the 8 lower address bits to allow the user to directly select up to 256 input or 256 output ports. A0 is the least significant address bit.

D0-D7 (data bus)
Tri-state input/output, active high. The data bus is used for data exchange with memory and I/O devices.

MREQ* (memory request)
Tri-state output, active low. The memory request signal indicates that the address bus holds a valid address for a memory READ or WRITE operation.

IORQ* (input/output request)
Tri-state output, active low. The IORQ* signal indicates that the lower half of the address bus holds a valid address for an I/O READ or WRITE operation.

RD* (memory read)
Tri-state output, active low. RD* indicates that the CPU wants to READ data from memory or an I/O device.

WR* (memory write)
Tri-state output, active low. WR* indicates that the CPU data bus holds valid data to be stored in the addressed memory or I/O devic

WAIT* (wait)
Input, active low. WAIT* indicates to the CPU that the addressed memory or I/O devices are not ready for data transfer. The CPU continues to enter wait states for as long as this signal is active. This signal allows memory or I/O devices of any speed to be synchronized to the CPU.

INT* (interrupt request)
Input, active low. The Interrupt Request signal is generated by I/O devices. A request will be honored at the end of the current instruction fetch if the internal software controlled interrupt enable flip-flop (IFF) is enabled.

M1* (Machine Cycle One)
Output, Active low. M1* indicates that the current machine cycle occurs with IORQ* to indicate an interrupt acknowledge cycle.

RESET*
Input, active low. RESET* forces the program counter to zero and initializes the CPU.

I (clock)
Single phase TTL level clock.

CLOCK CIRCUITRY
Clock inverter U14, crystal Y1, resistors R11 capacitors C8 and C6 form a 4 mega tz oscillator that drive flip-flop U16. The flip-flop is connected as a divide by two

circuit to insure that the waveform will be a square wave at the required frequency of two megahertz. Resistor R12 provides the necessary pull up for the processor. The RESET circuit consists of diode CR1, resistor R9, capacitor C5 and inverters U15 and U14. When power is initially applied, the output of U14 will be at ground which holds the CPU in a RESET* state and capacitor C5 will begin to charge through resistor R9. When the voltage on C5 reaches the threshold of CMOS Schmitt trigger U15 (in approximately 1.5 sec), the output of U14 will go high removing the RESET* condition. The CPU will now run the power up software. CR1 insures that momentary power outages will dump the charge on C5 and revert to the RESET* state. A Z80 CTC counter/timer is used in conjunction with the Z80 CPU to provide realtime functions and future interfacing capabilities. It's operation will be discussed in detail throughout the text.

DMUX WAIT STATE GENERATOR

All data written to the Digital to Analog Converter (DAC) is done with OUTPUT instructions. To allow the DAC time to settle and the sample and hold capacitors time to charge up, WAIT states are introduced into all OUTPUT instructions below 80 hex. The WAIT state generator consists of U31, a dual four-bit counter cascaded to form an eight bit counter, a D-type flip-flop U33 and some associated gates.

As a starting point, assume the next instruction the CPU will execute is an OUTPUT instruction, then the logic states of the WAIT state circuitry will be as follows: The RESET pins, R1 and R2 of U31 will be at a logical 1, which is the RESET state & therefore, all the U31 outputs will be 0. The flip-flop U33, Q* output will be a logical 0 and the WAIT* line at a logical one, which is off.

When the OUTPUT instruction is executed, the CPU IORQ* line goes low, the A7 line will be low and the M1 line remains high. This will cause the U13 pin 3 output to go low, removing the RESET from counter U31. Pin 8 of U12 will be low sending its output high, which is inverted by U12, turning the WAIT* line on or low. Also, flip-flop U33 is clocked via inverter U14, sending its Q* output high. The action of flip-flop U33's output going high disables address decoder U34, forcing all of its outputs high, disabling all DMUX channels.

In this state, the OUTPUT instruction will be extended until the WAIT* line returns high.

Since the RESET has been removed from U31, it is now free to be clocked by the system clock. On the first rising edge of the system clock after the IORQ* has gone low, U31's Q0 output, pin 3, will go high clocking the 8-bit address latch U32 and clocking the DAC latch on the DMUX board via the D CLK line of connector S43 pin 9.

So far we have turned on the WAIT* line, inhibited all DMUX channels (on the DMUX board) and latched both address and data busses.

Continuing the OUTPUT instruction cycle three system clock cycles later, the U31 Q2 output, pin 5, goes high which, via inverter U21, applies a SET to flip-flop U33 forcing its Q* output low. This enables the address decoder U34, enabling the selected 4051 IC on the DMUX board. The appropriate sample and hold capacitor, also on the DMUX board, will now charge up (or discharge) to it's new output value and the channel will remain on until the next OUTPUT instruction is executed

The instruction ends after 12 more system clock cycles, when the Q0 output, pin 11, of U31 goes high sending the WAIT* line high (off) and the RESET condition is again applied to U31.

Note that address decoder U35, which is used to drive the multiplexer (MUX), operates similar to the DMUX address decoder U34 but does not use the turn-on delay from U33. Since the multiplexer does not multiplex the DAC output but rather front panel potentiometer wiper voltages, there is no settling time associated with it. Also, note that the latched A6 line from the U32 latch output does not drive U35. Therefore, it's decoded output will "fold over" on 40 hex boundaries instead of the 80 hex boundaries for the DMUX outputs. In other words, port 00 hex can also be addressed by addressing 40H.

FRONT PANEL AND KEYBOARD CIRCUITS

In the central portion of the schematic are ICs U17-20 which are 74LS138 address decoders. These handle the various memory mapped ports for the FRONT PANEL controls and switches using straight forward address decoding.

The keyboard circuit is in the upper right hand corner of the schematic and uses latches U26, U27 and U28. U26 and U27 are CMOS hex tri-state buffers divided into a section which uses six buffers and a section which uses two buffers each with a separate enable. All six buffers of U27 are used in conjunction with two buffers of U26 to form an eight bit buffer. This eight bit buffer and latch U28 are connected to the keyboard which is wired in a column and row matrix with a diode in series with each key.

Keyboard decoding is accomplished by WRITING all "zeros" to latch U28 and then reading the U26/U27 buffer output. Since the inputs (keyboard side) of the buffers have pull-up resistors, R28-R35, no keys down will result in all "ones" being READ. If this is the case, no further decoding is necesary, however, if other than all "ones" is READ at least one key is down and the keyboard must be fully decoded. This is done by WRITING data to latch U28 that will set one selected row low while all other rows are high and then reading the column data at buffer U26/U27. Whenever data other than all "ones" is READ from the buffer, in the row where the "zero" was WRITTEN, this indicates that one or more keys are down, therefore the column must be decoded. Columns are decoded by shifting the byte that was READ from the buffer. After the first row has been decoded the next row (starting from 00 and moving towards 07) is set to "zero" and all other rows will be high or "ones". This operation continues until all 8 rows have been

decoded. If there are several notes played polyphonically, the diodes across each note prevent shorting of columns to columns and rows to rows. The priority structure scans down and across to find closures and scans progressively from memory, decoding up to a maximum of ten notes.

BATTERY BACKUP

RAM battery backup is accomplished by a 78M05C 5-volt regulator that is used to generate a 5.6 volt supply for the RAMS. A 5.6 volt supply voltage is obtained by using a diode drop in the common leg of the regulator to ground which biases the common to +0.6V. The diode in series with the output drops it back down so at the junction of the three diodes, CR4, CR5 and CR6, the VRAM supply ends up at approximately 5 volts again under normal circumstances. A lithium battery voltage source provided through diode CR6 supplies power to the RAMs when the VCC supply drops. When power is lost, the RAMs can be damaged if the input voltages to the RAMs are still at or near 5 volts while the VRAM supply has dropped to the 2 or 3 volt battery level. To prevent this, the diode CR8, resistor R23 and capacitor C14 on the input, hold the non-battery VRAM supply up longer than the VCC. Thereby, VRAM only drops to the battery voltage after VCC has dropped below it.

POWER SHUT-DOWN CIRCUIT

Just below the battery backup circuit is the power shut-down circuit, consisting of U23A, Q1 and associated components. CR2 is connected, through harnessing, to the power supply transformer secondary ahead of the main filter capacitor on the +15V supply. The raw AC voltage is half wave rectified by CR2, filtered by C11, R18 and R19 and clamped from going above +5V by CR3. This results in a half-wave rectified waveform clipped at +5V with a rise time following the line voltage and an extended fall time. The fall time is extended enough so that the voltage level under normal circumstances will not fall below the threshold of +1V, set by R20 and R21, on pin 2 of U23A. When power does go down, even briefly, the lack of input to CR2 will cause pin 3 of U23A to fall below the threshold sending its output to zero, dumping the charge on C10 and turning on Q1, which disables the RAMS via gate pack U22. The filter capacitors in the power supply are large enough to hold the supplies up for 15-20 milliseconds. Restoring power will allow the U23A output to go high again, but since it has an open collector output, it's only pull-up is R15, therefore, Q1 will remain on until C10 can charge up. This delay insures that the power supplies will be stabilized before the RAMS are enabled.

CTC COUNTER/TIMER

The Z80 CTC contains four eight-bit, programmable down-counters. It is I/O mapped between 80H-83H and used for the front panel LED multiplexing, AUTOTUNE and CASSETTE I/O routines, generally all the real time functions. One channel is used as a counter that is programmed to generate interrupts at every 1.25 millisecond intervals. These interrupts suspend the main system program loop to service the front panel DISPLAY and LED multiplexer routine.

INTERFACE JACKS

The FOOT SWITCH and FOOT PEDAL interface buffer is U30 at the central right hand portion of the schematic. This CMOS hex tri-state buffer handles the FOOT PEDAL single bit inputs such that the processor can treat them as memory locations. It monitors J7, J8, J9 and J10, the RELEASE, HOLD, PROGRAM ADVANCE and PROGRAM BACKSTEP jacks and the two FOOT PEDAL controller input jacks J2 and J3. Pullup resistors set U30 high such that a switch closure to ground READS in either a zero or one for a specific bit. The CASSETTE I/O jacks J14, J15 and J16 are mapped similarly. The single bit input from J2 and J3 is used to prevent a possible operational trap that would occur if the FOOT PEDAL VOLUME was programmed ON from the FRONT PANEL and no FOOT PEDAL was plugged into either J2 or J3, causing the instrument output volume to be zero. Nothing plugged into J2 or J3 will cause the system to disregard the FRONT PANEL programming and turn the FOOT PEDAL VOLUME off. The MODULATION OSCILLATOR'S SQUARE WAVE output is routed through the normally closed switch on jack J11 to level translator Q2. The MODULATION OSCILLATOR is applied to the data buss by buffer U26 and used as a time base for the ARPEGGIATOR. The MODULATION OSCILLATOR can be replaced as a time base by supplying an external clock to J11.

The CASSETTE OUTPUT uses the Q0 bit output from the keyboard circuit latch U28. This would seem to create a conflict between the two circuits but since the CASSETTE I/O routines suspend all other operations during their execution, this problem does not occur. The cassette transport on/off control circuit consists of flip-flop U33, Q3 and the relay. WRITING a "one" to bit D0 at the address mapped by U18, latches a "zero" at the U33 output, turns off Q2 and energizes the relay, turning on the tape transport. Similarly, writing a "zero" will turn the tape transport off. Diode CR9 shunts the back EMF developed by the relay coils, collapsing the field during turn-off which could otherwise damage Q2. The cassette output from the tape recorder is input via R45 and C19 to the inverting input of comparator U23B which is biased at +2.5V by resistor R43 and R44. The threshold on the non-inverting input of U23B is +2.5V or set by R41 and R42 with +/-120 mV of hysteresis determined by R40. Cassette data from the output of U23B is applied via buffer U26 to the data buss where it can be READ by the CPU. One of the CTC channels is used in conjunction with the cassette load routine to provide the time measurement necessary to determine "zero" or "one" data in.

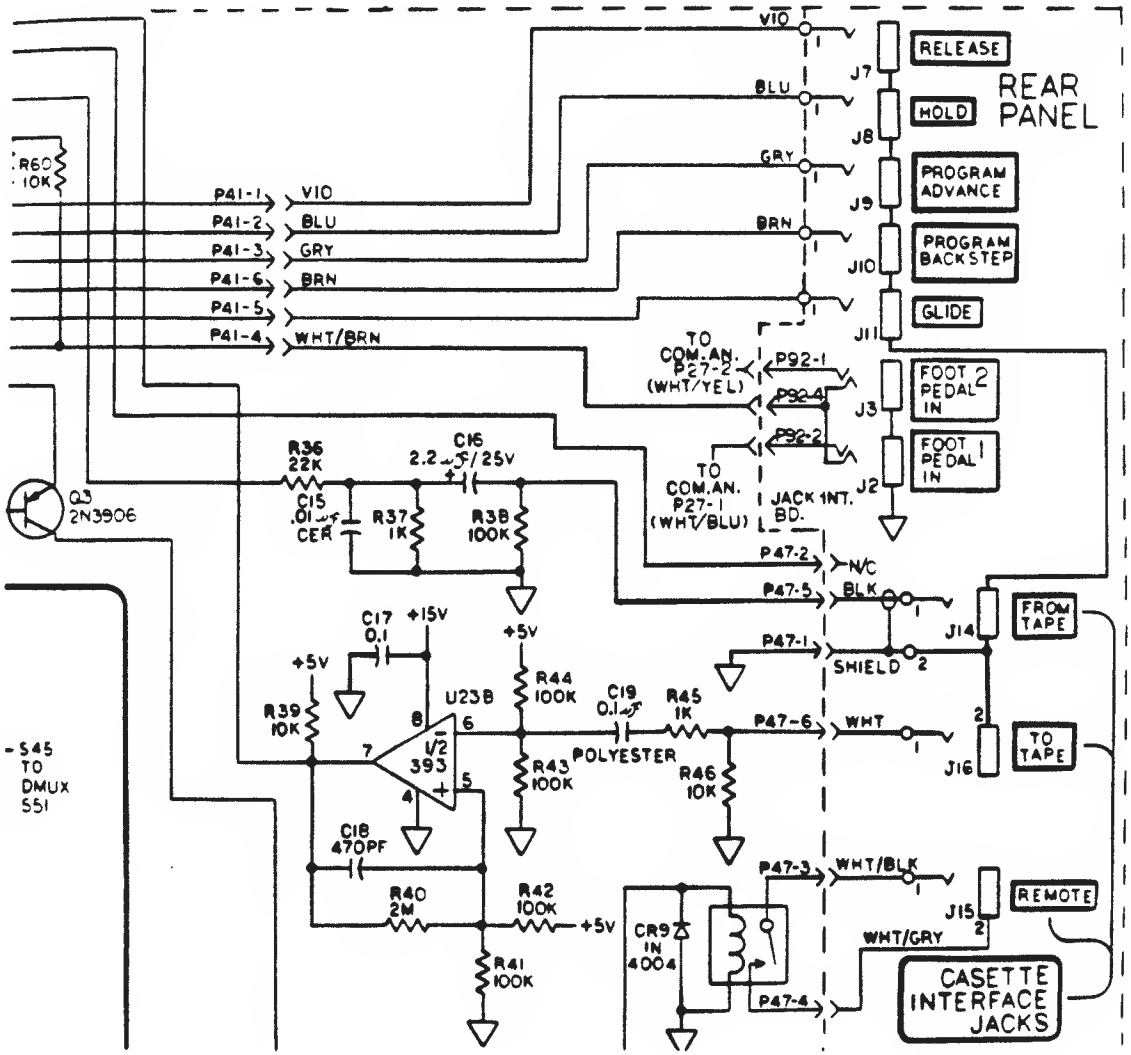
AUTOTUNE

The AUTOTUNE circuit uses two channels of the CTC chip, flip-flop U16 and one section each of U13 and U15. By selective voice triggering and manipulating oscillator levels, any one of the eighteen audio oscillators can be applied to the pin 1 input of Schmitt trigger U15. After each oscillator's uncompensated frequency has been measured, the AUTOTUNE

compensation value is calculated. It is then output via the DAC and DMUX to the corresponding oscillator summing node. One channel of the CTC is programmed as a "timer" and the other as a "counter". Channel three is the "timer" and is clocked by the 2mHz system clock, through a divide by 16 circuit which prescales it in the CTC, yielding an internal clock period of 8uSec. Timing begins when the CTC receives a positive edge on its pin 20 the CLK/TRG3 input. Channel two is the "counter" and counts negative edges at its pin 21 CLK/TRG2 input. Using these two channels results in a method of measuring "time"and "counting" oscillator cycles. Flip-flop U16 and gate U13 allow the timer and counter channels to be started synchronously by the falling edge of oscillator under test. The pin 10 SET input of U16 is connected to memory mapped latch U28 so that the flip-flop can be held in its SET state until the AUTOTUNE routine is ready to make a frequency measurement. Upon removal of the SET from the flip-flop the next falling edge of the output goes to a "one", starting the channel three CTC timer and enabling gate U13, the oscillator will now appear at the pin 6 U13 output to be counted by the channel two CTC counter.

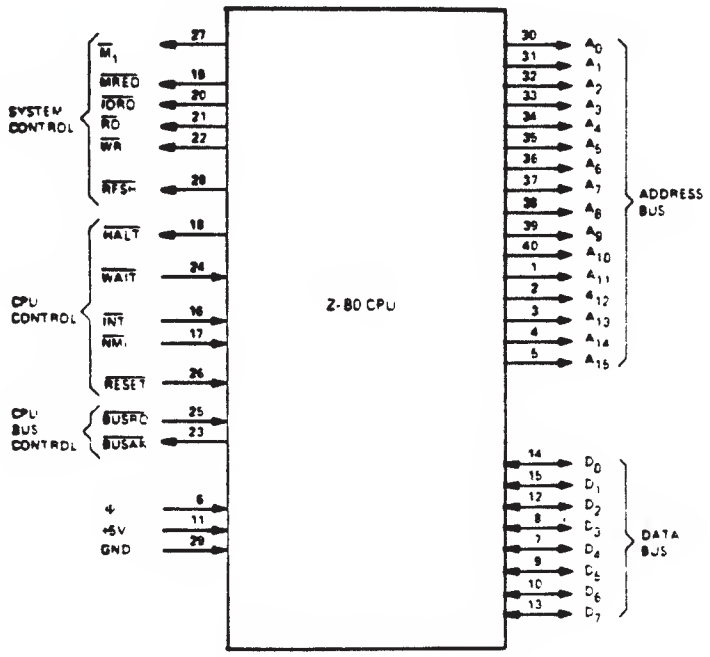
FUTURE EXPANSION

At the center of the schematic is an extra 40 pin DIP socket in which extra ROM, RAM or other hardware could be added in the future. These ports could latch data into the DAC for an appropriate use.



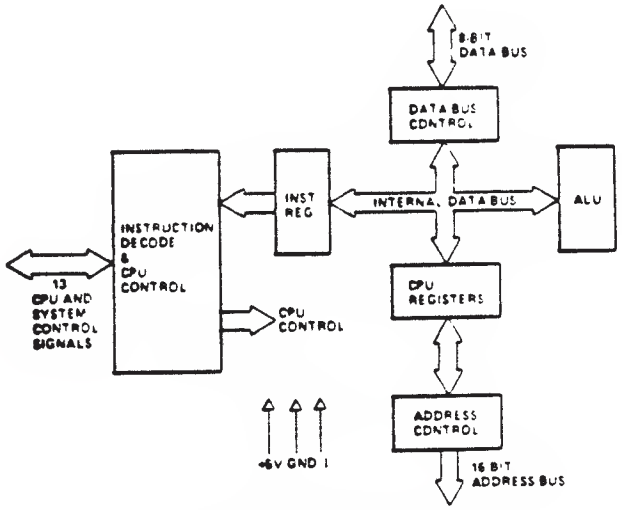
Z-80 CPU PIN DESCRIPTION

The Z-80 CPU is packaged in an industry standard 40 pin Dual In-Line Package. The I/O pins are shown and the function of each is described below.

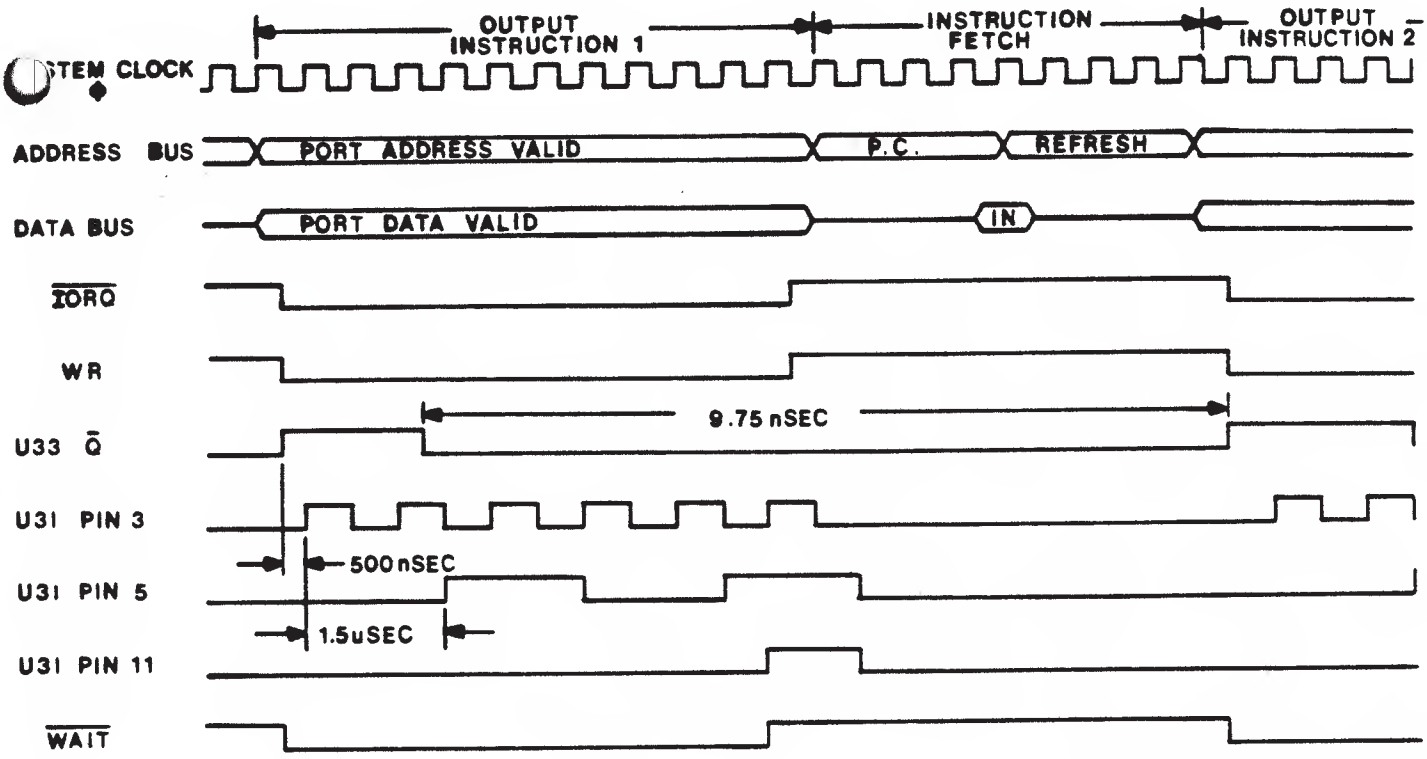


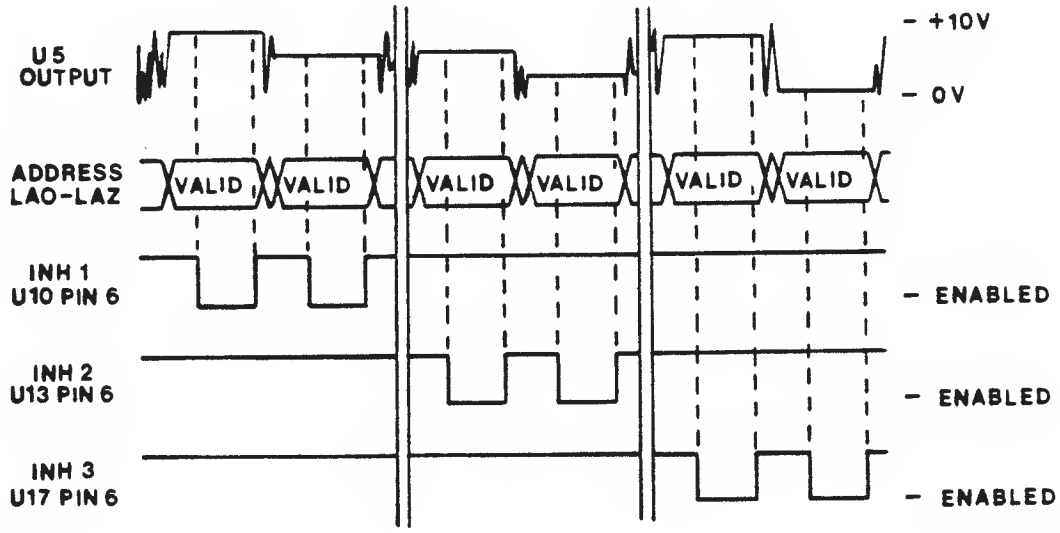
Z-80 PIN CONFIGURATION

Z-80 CPU ARCHITECTURE

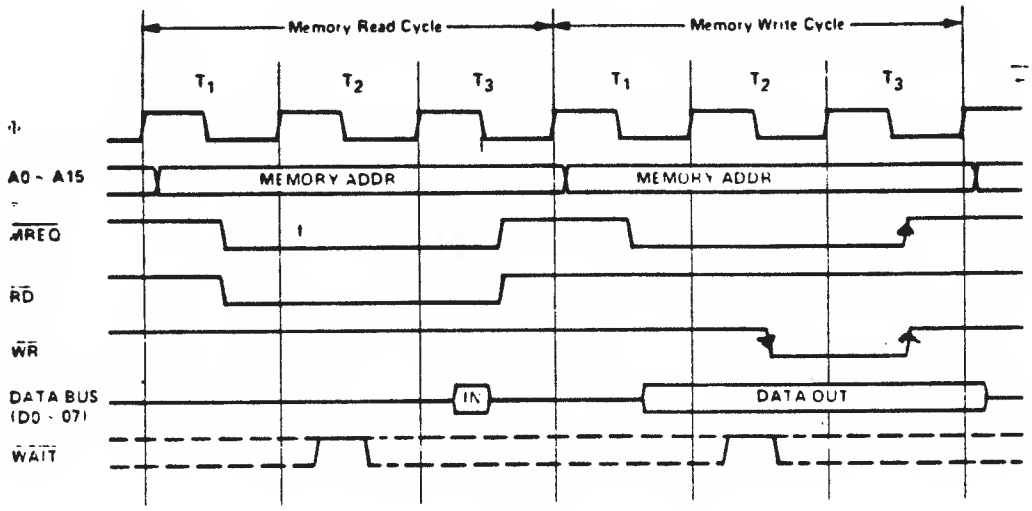


Z-80 CPU BLOCK DIAGRAM

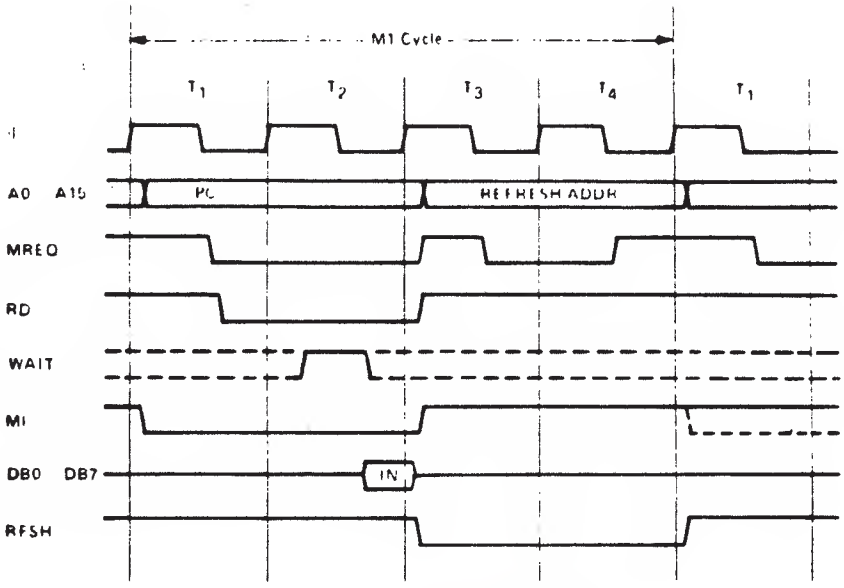

OUTPUT INSTRUCTION 1
INSTRUCTION FETCH
OUTPUT INSTRUCTION 2
STEM CLOCK
ADDRESS BUS
PORT ADDRESS VALID
P.C.
REFRESH
DATA BUS
PORT DATA VALID
IN
IORQ
WR
9.75 nSEC
U33 Q̄
U31 PIN 3
500nSEC
U31 PIN 5
1.5uSEC
U31 PIN 11
WAIT
MEMORYMOOG
WAIT STATE GENERATOR


U5 OUTPUT
+10V
0V
ADDRESS LA0-LAZ
VALID
VALID
VALID
VALID
VALID
VALID
INH 1 U10 PIN 6
ENABLED
INH 2 U13 PIN 6
ENABLED
INH 3 U17 PIN 6
ENABLED

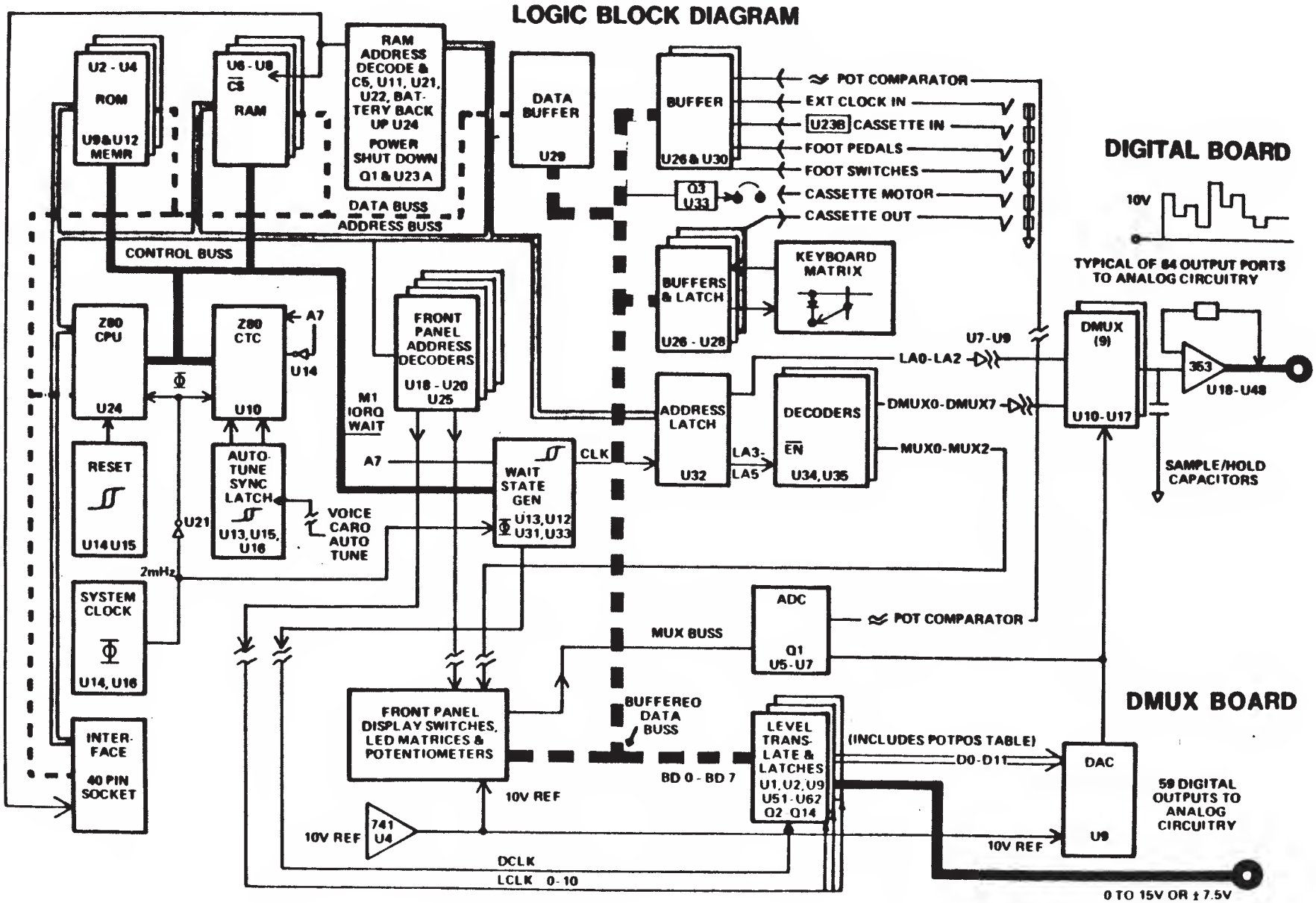
DEMUX



MEMORY READ OR WRITE CYCLES



INSTRUCTION OP CODE FETCH


LOGIC BLOCK DIAGRAM
U2 - U4
ROM
U9&U12
MEMR
U6 - U8
CS
RAM
RAM ADDRESS DECODE & C5, U11, U21, U22, BAT-TERY BACK UP U24
POWER SHUT DOWN Q1 & U23 A
DATA BUSS
ADDRESS BUSS
CONTROL BUSS
DATA BUFFER
U29
BUFFER
U26 & U30
POT COMPARATOR
EXT CLOCK IN
U23B CASSETTE IN
FOOT PEDALS
FOOT SWITCHES
Q3
U33
CASSETTE MOTOR
CASSETTE OUT
DIGITAL BOARD
10V
TYPICAL OF 64 OUTPUT PORTS TO ANALOG CIRCUITRY
BUFFERS & LATCH
U26 - U28
KEYBOARD MATRIX
Z80 CPU
U24
Z80 CTC
U10
A7
U14
Φ
FRONT PANEL ADDRESS DECODERS
U18 - U20
U25
M1
IORQ
WAIT
U7-U9
LA0-LA2
DMUX (9)
U10-U17
353
U18-U48
ADDRESS LATCH
U32
LA3-LA5
DECODERS
EN
U34, U35
DMUX0-DMUX7
MUX0-MUX2
SAMPLE/HOLD CAPACITORS
RESET
U14 U15
AUTO-TUNE SYNC LATCH
U13, U15, U16
VOICE CARO AUTO TUNE
A7
WAIT STATE GEN
U13, U12
U31, U33
CLK
U21
2mHz
SYSTEM CLOCK
U14, U16
ADC
Q1
U5-U7
POT COMPARATOR
MUX BUSS
DMUX BOARD
FRONT PANEL DISPLAY SWITCHES, LED MATRICES & POTENTIOMETERS
BUFFERED DATA BUSS
LEVEL TRANS-LATE & LATCHES
U1, U2, U9
U51-U62
Q2 Q14
(INCLUDES POTPOS TABLE)
D0-D11
DAC
U9
59 DIGITAL OUTPUTS TO ANALOG CIRCUITRY
INTER-FACE
40 PIN SOCKET
BD 0 - BD 7
10V REF
741
U4
10V REF
10V REF
DCLK
LCLK 0-10
0 TO 15V OR ± 7.5V

DEMULTIPLEXER BOARD #5

The purpose of the demultiplexer is to convert the serial current pulses from the DIGITAL board to parallel voltage outputs to drive the analog circuitry.

Analog data, specifically from the DAC, consists of serial current pulses with a variable magnitude of 0 to 3.32 mA. These current pulses are converted to a serial voltage pulse stream with a directly proportional magnitude between 0 and 10V, by U5. Capacitor C5 damps U5 to minimize overshoot and ringing. Also note the DAC will constantly convert its buffered data lines to analog current, sending it to the DEMULTIPLEXER. Valid information is separated by inhibiting the 4051 demultiplexer during times when invalid data is present at the DAC output.

Referring to left hand portion of the DMUX BOARD schematic, U10 through U17 are digitally controlled analog switches, each of which function as an 8 pole single throw electronic switch. One of these devices is selected using the inhibit inputs DMUX0 through DMUX7 on pin 6 which is controlled from the DMUX driver circuit on the DIGITAL board via level translators U7 through U9. Each device is driven by address lines LA0, LA1 & LA2 from the CPU on the DIGITAL BOARD, via the level translators of U7. These three address lines will select which of the 4051 eight outputs is connected to the input.

By using the three address and eight inhibit lines a connection is made from the output of U5 to 1 of the 64 sample and hold buffers. Since the CPU synchronizes the address changes with the serial analog output of the DAC, analog data will be channeled via the DEMULTIPLEXER to it's respective port.

OP AMPS U18-U48 are connected as buffers and capacitors C7-70 form the sample & hold ports. The timing of the demultiplex operation is accomplished by: addressing an input port using LA0-LA2; data output through the DAC and U2B; a 4uS enable delay; one of the demultiplexer chips outputing a specific voltage; a 12 microseconds "on" time; and the operation ending with the next port addressed and repeating the operation. Before any of the demultiplexer chips are turned "on", the 4uS delay allows time for the DAC to make its conversion and for some settling time for U2B. The 12 microseconds "on" period allows sufficient time to charge the holding capacitors for worst case conditions.

When a demultiplexer port is accesssed, the corresponding capacitor on the output will charge (or discharge) to the voltage that is output during the 12 uS "on" time. When the output is turned off, the capacitor holds the charge voltage until it is refreshed by the next "scan" through the demultiplexer routine. Since the input impedance of the buffer is extremely high, very little leakage or charge drain off from the capacitor will occur. Therefore, it will stay virtually at the voltage it was initially charged to between "scans".

SAMPLE/HOLD CIRCUIT

The series of 4051 demultiplexer IC's act like a giant commutator, in which the LA0, LA1 and LA2 lower order latched address lines are bussed together with specific chip selection accomplished by the appropriate inhibit line. From the earlier text, remember that on the DIGITAL BOARD, the address decoding is accomplished on the three higher order address lines - A4, A5 and A6, resulting in the DMUX0-DMUX7 lines. Since the 4051s are operated between ground and +15V, their address lines are level translated from TTL to +15V by open collector buffers U7, U8 and U9. Each 4051 is followed by a 353 BIFET op amp buffer such as U18A and a sample/hold capacitor such as C7. For neatness, only two circuit configurations are shown on the top and bottom of the schematic and the remaining 62 are noted only in rectangular boxes. Below the DAC is U6B, a 393 comparator and a 2N3906 transistor Q1 which form a hysteresis circuit.

10V DAC REFERENCE

Looking at the upper left hand portion of the schematic, the DMUX BOARD has a 10 volt temperature compensated DAC reference voltage source. It is used for all the analog linear data and consists of zener diode CR1 and 741 buffer U4.

DAC CIRCUITRY

All digital to analog and analog to digital conversion is done using the 12-bit DAC U3, 8-bit data latch U2, 6-bit data latch U1, current to voltage converter U5 and successive approximation comparator U6A. C2 and C4 are supply decoupling capacitors, C3 sets the [illegible] frequency compensation, R10 provides [illegible] ADJUSTMENT and R8 sets the FULL SCALE level of 10.000V, with the upper eight bits ON and the lower four bits OFF. Data requiring digital to analog conversion is done simply by OUTPUTTING the data to its corresponding port address where U3 makes the conversion.

A/D CIRCUITRY

Analog to digital conversion of a front panel potentiometers(pots) requires that a software generated successive approximation routine be used. Since the DMUX and the MUX (multiplexer) run synchronously, data can be written to the DAC with all DMUX channels off, while addressing the multiplexer at the same time (except that the MUX addresses "fold over" at 40M, as described earlier in the DIGITAL board section). This is true because any OUTPUT instruction between addresses 40H and 80H will WRITE data to the DAC, but all DMUX 4051s will be off. Since the multiplexer addresses "fold over", a pot with an address in the 0H to 40H range will be put on the MUX buss. The MUX buss comes in from the DMUX board on P516-1 and for the moment disregarding CR2, CR3 and R18-R20, is applied to the non-inverting input of comparator U6A. The DAC is connected to the inverting input of U6A and the U6A output is connected via P517-1 back to the DIGITAL board where its status can be READ by the CPU. An A/D conversion is accomplished by OUTPUTTING approximations to the D/A converter with the address of the pot to be converted plus 40H. For example, if a pot with an address of 10H was to be converted, the first approximation

would be to OUTPUT 80H, which is about +5V, to port 50H (10H + 40H). The +5V approximation appears on pin 2 of U6A via the D/A converter and the pot value on pin 3 of U6A via the multiplexer on the FRONT PANEL board. By now, reading the U6A comparator output, the CPU knows whether the voltage on the pot wiper is higher or lower than the +5V approximation. Assuming the pot voltage was higher than +5V, the next approximation would be 7.5V. This approximation routine continues with successively smaller steps - each, half the previous step, until the pot value has been determined.

POTENTIOMETER EDITING

Pot editing is accomplished by detecting pot movement. When a pot is moved, its output replaces the stored program data from memory. In order to detect pot movement, all pot positions must be known at all times. When the unit is turned on it runs a power-up software routine that converts all the analog pot voltages to digital data and records this data in a position table called POTPOS. This POTPOS table is constantly updated in order to maintain current pot position information. The software for the main system loop software contains a routine that systematically outputs the POTPOS table data to the DAC while addressing the multiplexer, to apply the corresponding pot value to the MUX buss. The comparison is done by comparator U6A with hysteresis provided by Q1, U6B, CR2, CR3 and R17-R21. Since, in the case of a pot that has not been moved, both voltages on the inputs of U6A will be nearly equal, some threshold hysteresis is required. By WRITING a zero to the U2 latch Q4, output Q2 will be turned on pulling R17 to +15V. CR2 will be forward biased and will therefore clamp the junction of R17 and R18 to about +0.6V above the MUX buss potential. This will yield a constant drop across R18 of about 0.6V over the normal range of 0V to +10V of the MUX buss. R18 and R19 form a simple divider with the voltage appearing on the U6A input at about 50mV higher than the MUX buss input. This forms the positive hysteresis threshold to detect pot movement while in a similar manner U6B, CR3 and R20 generate the negative limit. If a pot is found to be outside these limits when compared to its latest position, information from the POTPOS table is determined to have been moved and put into EDIT.

LEVEL TRANSLATION

Numerous switching functions of the analog synthesizer must be controlled and their data is latched by hex latches U51, U52 and U54-U61. Since the analog data of these switch controls have various levels, their on/off control lines switch from +7.5V to -7.5V, 0V to +15V or as TTL levels. Buffer U50 and transistors Q2-Q7 translate six bits of the buffered data buss to the +7.5V to -7.5V level and the 0V to +15V level. Buffer U53 and Q8-Q12 translate the CLOCK LINE to the +7.5V to -7.5V level.

READING RECOMMENDATIONS

The following books are recommended for additional information on micropeocessors like the Z80. These are general references not related to MEMORYMOOG but contain important system concepts.

TRS-80 MICROCOMPUTER TECHNICAL REFERENCE HANDBOOK, Catalog 26-2103, 1978.

PROGRAMMING THE Z80 by Rodney Zaks, 1980 2nd Edition from SYBEX C280, Printing 10587654321 1SBNO-89588-047-4.

FRONT PANEL CONTROL BOARDS #6 & 7

Left and right side control board (L.S.C. & R.S.C.) switch cicuitry is almost identical to the keyboard decoder column/row matrix discussed earlier. A 74LS377 latch is on the left side of the L.S.C. board and a 4503 buffer on the left side of the R.S.C. board, connected through connector S75. Thus each board shares common rows. The only thing different compared to the keyboard matrix, are the diodes for each contact - since there is no need to detect multiple switch closures. The FRONT PANEL matrix has two-key rollover, whereby pressing more than two keys ends up shorting buss lines together which decode as an erroneous switch action that was not actually taken. It outputs all "zeros" on the latch and READS all "ones" on the buffer with no switches closed. If it finds anything other than "ones", it scans the latch outputs for the particular row, READS it to the buffer and then proceeds. It READS two bytes of information, first READING the left side, then the right side.

DISPLAYS

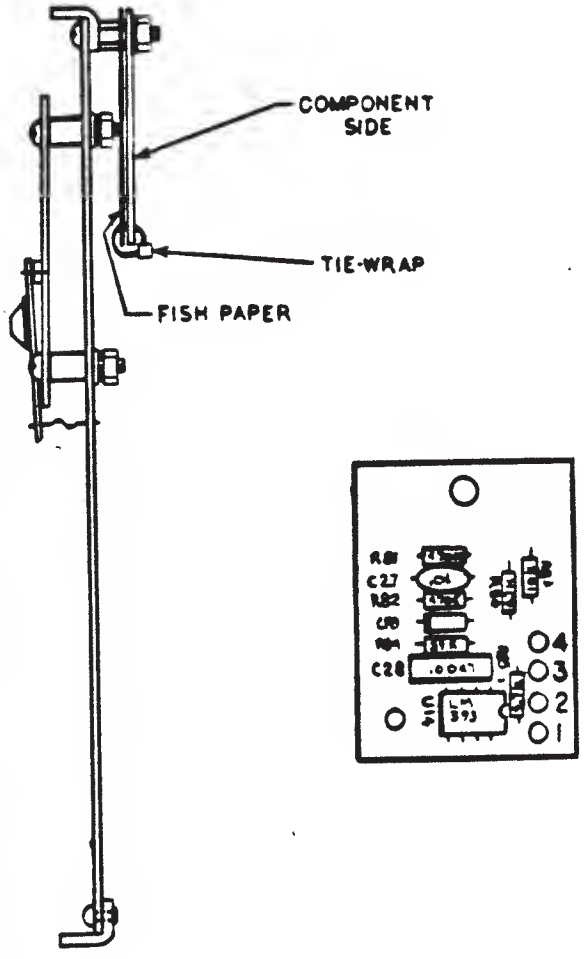
Front panel LEDs are also matrixed in a column and row structure. The row data is latched by U1 on the L.S.C. board which drives U2 and U3, also on the L.S.C., which are Darlington driver arrays that provide the necessary current gain. All discrete LEDs on both control boards, along with the eight character drivers for the alphanumeric display,are driven from the U2 and U3 row driver. Column data for the L.S.C. board discrete LEDs is latched by U8 with Q15-Q18 providing the necessary current gain. Column data for the fourteen segments of the alphanumeric display is latched by U4 and U5 with Q1-Q14 providing current gain. The discrete LEDs on the R.S.C. board column data is latched by U2, on the R.S.C., with Q1-Q4 providing current gain. All the above described latches are memory mapped (meaning they are WRITTEN to as if they were memory) by address decoders on the DIGITAL board described in the DIGITAL board section. The LEDs (including the alphanumeric display) are multiplexed at a one eighth duty cycle with a 100Hz loop rate. This timing is determined by interrupts generated by the CTC on the DIGITAL board as described earlier. Only one row will be on (an output from U2 or U3 low) at any time, while from a table in memory, the corresponding column data (which has been stored there previously) is obtained and WRITTEN to the column latches U8, U4 and U5 on the L.S.C. and U2 on the R.S.C.

The two digit program display consists of a simple 7447 seven segment decoder, 74LS378 latch and two MPSU55 drive transistors. The software routine is similar to the LEDs except that there are only two drives, with the tens and the units digits alternating on each interval pot. A small additional board has been added to early MEMORYMOOG versions to the L.S.C. control board utilizing a 74LS273 in the U1 position which deselects the eight character display and LEDs in the event of a power-down situation. This avoids possible LED damage due to the application of a constant voltage to the LEDs which are normally multiplexed. The 74LS273 has a COMMON CLEAR input which deselects the LEDs if a low voltage condition exists.

All pots are connected between the analog ground and the plus 10 volts which is driven from the 10 volt reference source generated in the DMUX BOARD. The drive to all the pots is in parallel and addressed from the same latched and buffered liñes as developed on the DIGITAL board.

6-VOLT DISPLAY REGULATORS

There is a series of 6 volt regulators on the lower right corner of L.S.C. schematic which supplies all the lights. The 5 volt supply is not used because of the diode drops from the Darlington 2704s which have a saturation voltage of about one volt, the 2N3906 PNP transistors and the two volt drop across each LED would provide little voltage across the current control resistors R74, R75 and R76. Therefore, the 6 volt regulators are powered by the RAW 5 volt supply (provides approximately 12 volts) which averages an 800 milliamp draw. The regulated 6 volts is divided up in a seemingly haphazard fashion but this in fact balances the current throughout the FRONT PANEL.



VOICE CARDS BOARD #1 A THROUGH F

THE OSCILLATORS

Starting at the upper left hand corner of the schematic is OSCILLATOR ONE consisting of a 3340 VCO which outputs TRIANGLE, SAWTOOTH and variable width rectangular pulse waveforms. Refer also to the accompanying VOICE CARD block diagram. Since loading of the TRIANGLE and SAWTOOTH outputs can effect the oscillator frequency slightly, high value base resistors are used. Each one of the outputs feed a 4016 switch and a 3360 VCA. All the waveforms are summable such that SAWTOOTH, TRIANGLE and rectangular pulse waveforms are available at the same time. The variable width rectangular PULSE waveform is established by the control signals coming from the COMMON ANALOG board where the pulse width for all voices is set.

There is a provision for PULSE WIDTH MODULATION and also VOICE MODULATION on each VOICE CARD with OSCILLATOR THREE used as the modulation oscillator. All oscillator signals are summed into a 3360 VCA which is controlled by the AMOUNT CONTROL programmed from a DMUX board DAC amount. Following the 3360 everything is summed into a TL072 U12A. At high volume settings, the signal is clipped in the TL072 for a desirable sounding "distortion effect". The output from the summer goes into Q3, a 2N3904, which is bussed to the AUTOTUNE circuit. Since six VOICE CARDS are bussed together, there is a need for a way to select a particular VOICE CARD and OSCILLATOR. To accomplish this, the collector of Q3 is tied to the FILTER CONTOUR for each VOICE CARD, thereby providing the VOICE CARD selection. Then by turning on the AMOUNT CONTROL for a particular OSCILLATOR and obtaining an independent contour from the CONTOUR/GLIDE board, a specific OSCILLATOR on a particular VOICE CARD can be selected.

The selection process applies a voltage on R131 which allows Q3 to turn on and using the rectangular pulse waveform from the OSCILLATORS, a pulse is obtained. It is coupled to CR1 and sent out to the AUTOTUNE buss to the DIGITAL board. The U12A sums the OSCILLATORS with a NOISE buss from the COMMON ANALOG board. One NOISE source generates the NOISE for all VOICE CARDS and is routed into the filter.

THE VCF

The VCF filter is a 24dB/octave patented Moog filter and it uses an IT122 monolithic matched transistor pair at the top and bottom of the filter ladder to cut down on voltage offsets and improve the current control signal rejection.

All the outputs of the OSCILLATORS and the NOISE source are coupled to the base of Q11(2) via C26. Q11 (1 and 2) convert the input signal to a differential signal current in the ladder. The collector, capacitor C31, and the next set of emitters Q9 and 10 form a 1 pole current controlled low pass filter. The cutoff frequency of the filter is directly proportional to the standing current in each leg of the ladder. The four stages in the ladder add up to a four pole low pass filter.

The filter ladder is controlled by current from an exponential current source U14 that also uses an IT122. The control current to the filter comes from many sources, such as: the FILTER CONTOUR of the CONTOUR/GLIDE board, the KEYBOARD VOLTAGE, COMMON ANALOG control signals which sum the FILTER CUTOFF, FREQUENCY MODULATION and OSCILLATOR 3 MODULATION. All are summed together, scaled with R167 and offset adjusted with the RANGE adjust R164 and applied to the exponentiator that drives the VCF. The filter signal is obtained differentially by a 353 BIFET OP AMP U20A and U20B. The 353 has a gain factor of approximately 4, which brings the signal up to about 100 millivolts, when the filter is all the way up. That signal has enough drive to obtain distortion in U22, the 3080 OTA, for a "fat" overdrive sound. The distortion is severe enough to alter a triangle waveform into a sinewave at the output with the LEVEL controls up and the VCF "open" all the way. The offset is cancelled with VCA TRIM R140 which takes out any "thumping sounds".

Next, the signal is applied to a 3080 OTA, the EMPHASIS amplifier U21, where it is attenuated with R147, R148 and R149. It is attenuated because distortion is wanted in the final output VCA but NOT in the EMPHASIS circuit as it creates undesirable sound effects. The signal, in turn, drives the inverting input of Q11 to generate the EMPHASIS. The total phase shift of the filter is equal to 180 degrees at the cutoff frequency of the filter and this signal is injected into the minus input of the filter, resulting in positive feedback. This establishes a resonent peak in the filter response at the cutoff frequency. The height of the peak depends on the setting of the EMPHASIS control. At full emphasis the filter will oscillate producing a sine wave. EMPHASIS trim R153 sets the oscillation threshold and EMPHASIS BALANCE trim R151 cancels any voltage offset of U121.

The EMPHASIS control line comes from the COMMON ANALOG board, where all lines are bussed together such that one line controls all VOICE CARDS. The audio output from the 3080, U22, is fedback to the COMMON ANALOG board where it is summed with the other five VOICE CARDS.

OSCILLATOR SYNCHRONIZATION (SYNC)

OSCILLATOR TWO is identical to OSCILLATOR ONE except for the SYNC capability. The SAWTOOTH output from OSCILLATOR 1 is applied through U3D, a 4016 switch to OSCILLATOR 2. When U3D is ON, it is differentiated from a narrow pulse which turns Q1 on and effectively shorts out the TRIANGLE output for about 100 microseconds. This discharges capacitor C12, the timing capacitor for OSCILLATOR 2, resulting in a complex SYNC waveform where OSCILLATOR 1 is free running and OSCILLATOR 2 is synchronized to OSCILLATOR 1. The fundamental frequency of OSCILLATOR 2 is now "locked" to OSCILLATOR 1.

CEM 3340

Voltage Controlled Oscillator

The CEM 3340 and CEM 3345 are completely self contained, precision voltage controlled oscillators, featuring both exponential and linear control scales and up to four buffered output waveforms: triangle, sawtooth, square, and pulse with voltage controllable pulse width. Full temperature compensation makes these VCOs extremely stable, and eliminates the need for a temperature compensation resistor. The highly accurate exponential and linear control inputs are virtual ground summing nodes, allowing multiple control voltages to be mixed within the device itself.

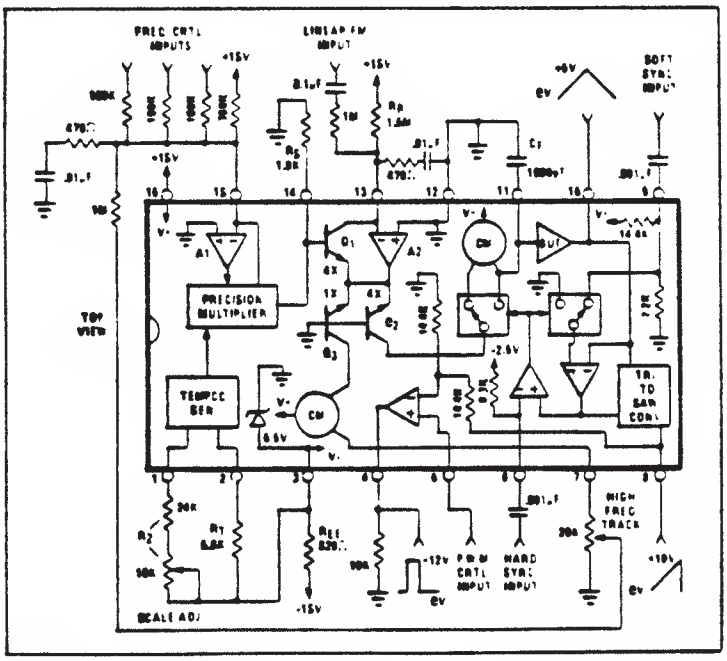
Also included is provision for hard and soft synchronization of the frequency, and an output for easy adjustment of high frequency tracking. Special care in the design ensures oscillation start-up under any power-on sequence and supply conditions.

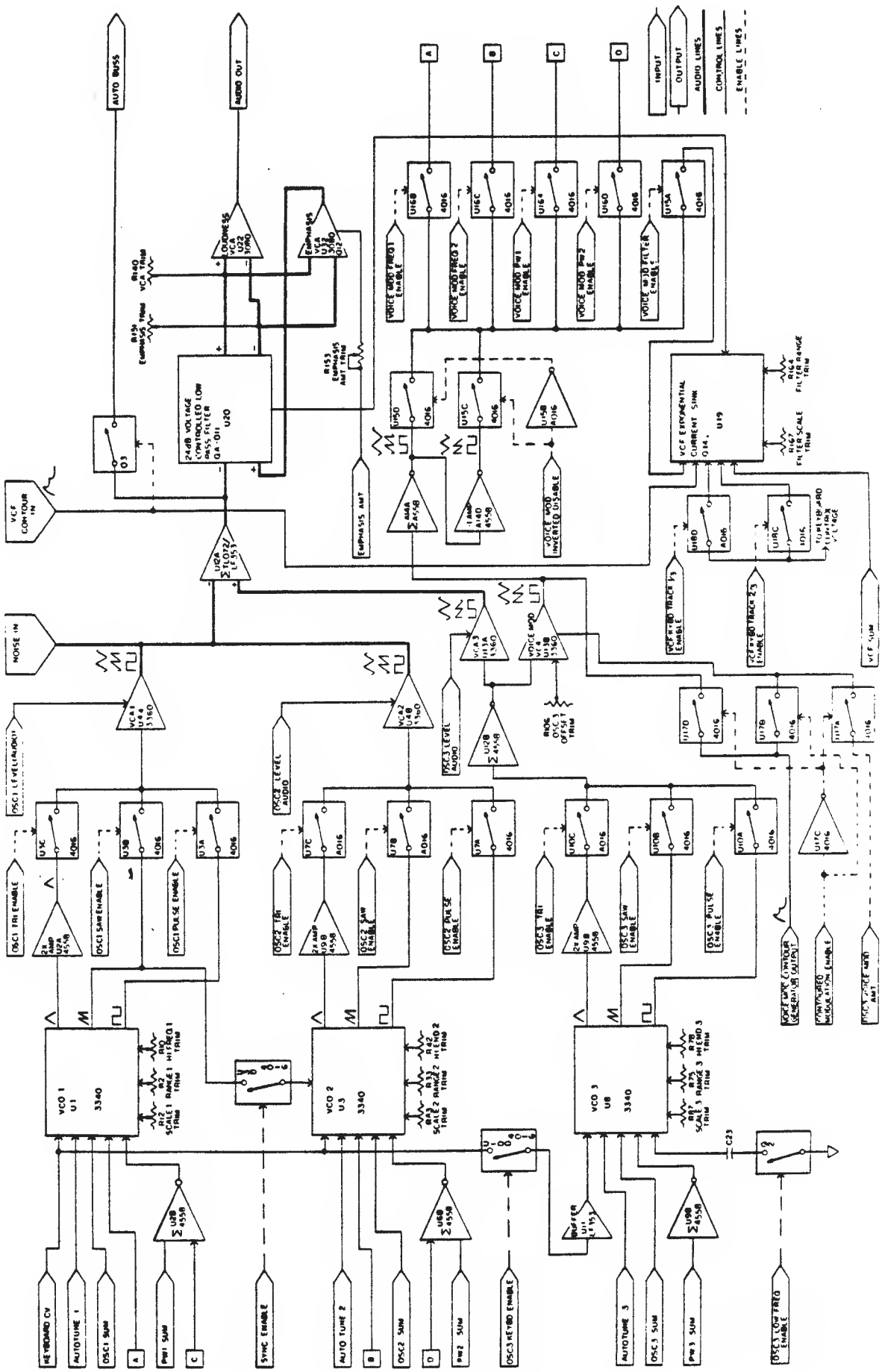
Although a low voltage process has been used to reduce die size, cost, and leakage currents, an on-chip 6.5 volt zener diode allows the device to operate off ±15 volt supplies, as well as +15,-5 volt supplies.

Absolute Maximum Ratings

Voltage Between V_{CC} and V_{EE} Pins	+24V,-0.5V
Voltage Between V_{CC} and Ground Pins	+18V, -0.5V
Voltage Between V_{EE} and Ground Pins	-6.0V,+0.5V
Voltage Between Frequency Control Pin or Reference Current Pin and Ground Pin	±6.0V
Voltage Between Multiplier Output Pin and Ground Pin	+6.0V, -1V
Current through Any Pin	±40mA
Storage Temperature Range	-55°C to +150°C
Operating Temperature Range	-25°C to +75°C

CEM 3340 Circuit Block and Connection Diagram

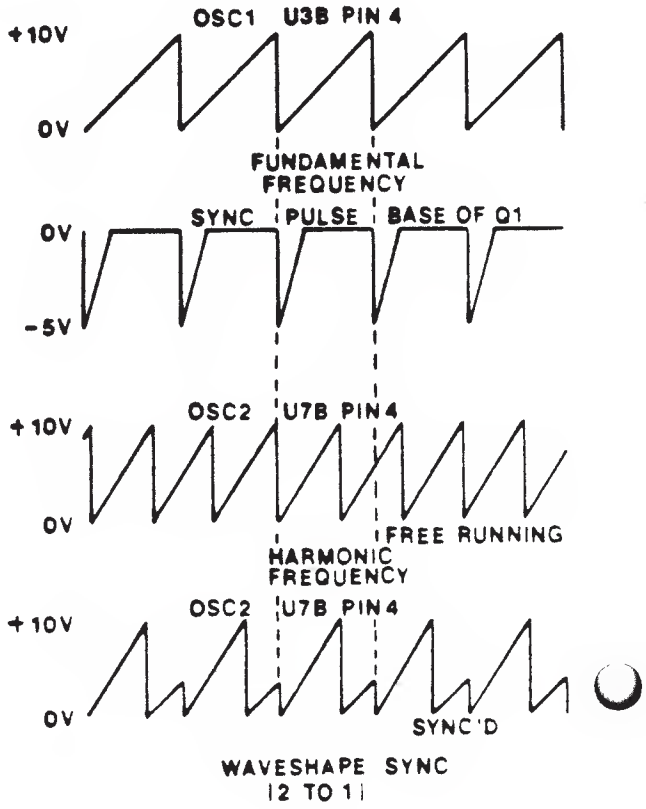



AUDIO BUSS
AUDIO OUT
INPUT
OUTPUT
AUDIO LINES
CONTROL LINES
ENABLE LINES
24dB VOLTAGE CONTROLLED LOW PASS FILTER
VCF CONTOUR IN
NOISE IN
VCF EXPONENTIAL CURRENT SINK
VCO 1
VCO 2
VCO 3
3340
KEYBOARD CV
AUTOTUNE 1
OSC1 SUM
PW1 SUM
SYNC ENABLE
AUTO TUNE 2
OSC2 SUM
PW2 SUM
OSC3 KEYBD ENABLE
AUTOTUNE 3
OSC3 SUM
PW3 SUM
OSC1 OCT FREQ ENABLE
VCF SUM

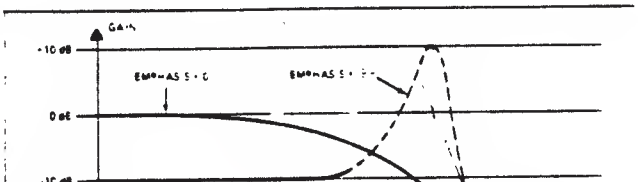
VOICE MODULATION
OSCILLATOR 3 also has a few differences from OSCILLATOR 1 in that the KEYBOARD VOLTAGE can be disconnected through the 4016 switch U10 and instead used as a modulation source. The modulation is only about one hertz, however, driving the 3340 VCO's with a control voltage input of such a low level causes the TRIANGLE waveform to be unsymetrical. Therefore, Q2 is used as a low frequency switch. With the low frequency switch on, Q2 is turned on and places a .033uf capacitor, C23, in parallel with the .001uf capacitor C22. This drops the frequency approximately 32 times or about five octaves. Since a DC output is needed from OSCILLATOR 3 for modulation, the three waveforms are summed by a TL072, U12B, and applied to two 3360 VCAs, U13A and U13B. U13A is used for establishing the level which controls the audio going into the summer and U13B is the VCA for VOICE MODULATION when OSCILLATOR 3 is used as a modulation source. To prevent bleedthrough through the 4016 transmission gates, the 3360, final VCA drive, is shut off by the software. In that way, turning off the WAVEFORM switches allows no bleedthrough because the 3360 is completely off. Again, U13B is the VCA for the VOICE MODULATION and its output is fed into inverter A14A and another inverter, A14B, resulting in an inverted and a non-inverted output. These two waveforms are made available with another modulation source, the FILTER CONTOUR VCA, from the CONTOUR/GLIDE board, providing either straight or inverted contours. Therefore, all standard and reverse waveforms are available which can be coupled through the various 4016 switches to inputs controlling OSCILLATOR FREQUENCY, PULSE WIDTH or FILTER CONTOUR.

Since everything is located on the VOICE CARD or at least associated with individual VOICE CARDS, this phenomenon is called VOICE MODULATION, which is "independent" for every VOICE CARD. It means that a selected TRIANGLE WAVEFORM can be turned on for OSCILLATOR 3, on a particular VOICE CARD and can have completely different, all independent, PULSE WIDTHS and FREQUENCIES. Similarly, the FILTER CONTOUR can be activated on a voice by voice basis capable of creating a sweeping effect of the OSCILLATORS. It is also possible to take the FILTER CONTOUR, turn the VCA all the way up and use that to control the VCA for OSCILLATOR 3. Then using the FILTER CONTOUR to adjust a slow ATTACK time would produce delayed modulation on a VOICE CARD by VOICE CARD basis.

-5 VOLT REGULATOR
The 3340 VCO's need to operate at +15V and at less than -7.5V, because they use a low voltage process. U23, a three terminal 79L05 -5Volt regulator, at the central right portion of the schematic, powers these chips for the negative rail. Operation then is at +15V and -5V.



WAVESHAPE SYNC
(2 TO 1)



VCF FREQUENCY RESPONSE CURVES

CONTOUR/GLIDE BOARD

POLYPHONIC GLIDE

The DMUX board generates six independent pitches for each of the VOICE CARDS. To add polyphonic glide to each voice, in the upper left-hand corner of the schematic is an input line labeled POLYGLIDE. It is basically a linear glide circuit which uses a 3360 VCA. The signal for each one of the VOICE CARDS comes in on lines S32-2 through 9 and is divided down with .01% matched resistors to obtain a precise 50% reduction. These lines are applied to a 4558 which is connected as a comparitor, the output of which drives the 3360 VCA. The 3360 is a current-in current-out transconductance multiplier with the current set by R5. The current out is equal to the current in times the control voltage on pin 3. The maximum gain is obtained when pin 3 is at +2 volts. For example, starting from zero volts at S32-9, then applying +10 volts, 5 volts would appear at the input of the 4558 which would drive the output on pin 1 high providing a positive drive current to the 3360. This would, in turn, generate another output current on pin 2 which is proportional to the control voltage on pin 3. C1 is charged with the current source yielding a linear RAMP voltage which Q1 will follow until the voltage on the source of Q1 equals 5 volts. At 5 volts, the 4558 output will go to zero, stop the charging current and hold it there, controlling the GLIDE time. The higher the control voltage on the 3360, the higher the output current, the faster 5 volts is reached. Therefore, the larger the control voltage on pin 3 of the 3360, the faster the GLIDE time.

The POLYGLIDE amount is bussed to all the GLIDE circuits and each pair of RANGE trimmer outputs are set for the maximum GLIDE time. The control of the dual 3360s is made by applying the same voltage to both pins 3 and 12 of each device which are the exponential inputs (the 3360 has its own internal exponentiator). Thus, POLYPHONIC GLIDE means that each individual VOICE will glide from the last note played on the keyboard.

MONOPHONIC GLIDE & EXTERNAL SYNTH (BOARD #9)

There is also a separate MONOPHONIC GLIDE output. Whereas six VOICE CARDS will not precisely track no matter how accurately they are adjusted, in POLYPHONIC GLIDE it doesn't matter because they move independently as played. But playing all six VOICE CARDS with MONOPHONIC GLIDE means they must all glide together. In the POLYPHONIC mode all the 3360's are turned ON and the MONOPHONIC GLIDE is turned OFF by setting it to the minimum. In the MONOPHONIC mode, the six 3360's are turned OFF and the MONOPHONIC GLIDE is turned ON. The GLIDE output is coupled through the TRANSPOSE circuit and goes back into the MASTER SUMMER on the COMMON ANALOG board so it will affect all the VOICE CARDS. It has a GLIDE RANGE trimmer but the second half of the 3360 is not connected. Also, this MONOPHONIC OUTPUT drives the small #9 board on the MEMORYMOOG back panel where two inverters, U1A and U1B, provide the EXTERNAL SYNTHESIZER CONTROL VOLTAGE (C/V) OUTPUT. SCALE and RANGE trims are accessible through the rear panel for adjustment of the MEMORYMOOG. The MONOPHONIC EXTERNAL SYNTHESIZER C/V OUTPUT tracks the low, high or last note depressed on the keyboard, depending on what is programmed. The control voltage output from the MONOPHONIC GLIDE circuit is summed in with the TRANSPOSE circuit.

TRANSPOSE

The TRANSPOSE circuit operates in a MONOPHONIC, POLYPHONIC and TRANSPOSER HOLD mode. In the HOLD MODE the MEMORYMOOG remembers what chordal notes were played last and will play those same three notes transposed based on the next note played. At the lower left hand corner of the schematic is the circuitry which buffers the TRANSPOSE signal consisting of U7B and associated OFFSET and SCALING trims R53 and R286.

ADSR CONTOUR CIRCUITRY

The contour lines enter from the DMUX board at the upper left hand portion of the schematic where the ATTACK, DECAY and RELEASE are buffered and applied to the 3310 Contour Generator. The usual ADSR contour includes an ATTACK, two holds and a RELEASE, but if a second note is played the contour would start back up from whatever DECAY or RELEASE setting it subsided to and reach its ATTACK setting more rapidly than is normal. This is not a desirable condition for the rearticulation of chords, therefore turning ON the RETURN TO ZERO FRONT PANEL switch causes the Contour Generator to short to zero, thus providing a rearticulation of the entire ATTACK phase of the chord. In the UNCONDITIONAL CONTOUR mode, once a trigger is established, the contour will continue & the entire ATTACK phase automatically will proceed into the RELEASE phase (if a note is not held down). In the KEYBOARD FOLLOW mode, the control voltage from the individual VOICE CARDS is used to reduce the ATTACK, DECAY and RELEASE times as notes are played up the keyboard. It is like a piano in which a note played on the bottom lasts a long time, while a note played at the top lasts only a short time. The keyboard follows or simulates that accoustic property with control voltages and as the keyboard is played with higher pitches, with the KEYBOARD FOLLOW switch ON, the DECAY, ATTACK and RELEASE get progressively shorter. There is also a RELEASE SWITCH which when OFF, the contour drops to zero immediately following the ATTACK, DECAY and SUSTAIN phases. When it is ON, the contour fades away at the rate set by the RELEASE potentiometers.

LOUDNESS ENVELOPE GENERATOR CIRCUITRY

All the contours are generated by a series of six 3310 Envelope Generators. There are five control voltage inputs for the ENVELOPE GENERATORS: ATTACK, DECAY, SUSTAIN and RELEASE and attack out. The 3310 has its own current mirrors, comparitor and exponential current sources. Therefore, by changing the voltage on pin 16 of U17, it changes the charge time during the ATTACK phase, thereby creating a voltage controlled Envelope Generator. Considering the 3310 as a straightforward Envelope Generator, every time a key is

depressed on the MEMORYMOOG, the keyboard logic decodes which note is on and which VOICE CARD it is on. Thus, pressing a key would result in one of trigger inputs A-F actuating. If TRIGGER A is on, for example, the trigger is coupled through the 74LS32 U16A to the input and is differentiated by C24 and applied to the 3310 trigger input. This starts the ATTACK phase.

Without a trigger, the Envelope Generator will not start but once the gate is on, U17 operates as a standard Envelope Generator. When the ATTACK phase reaches the maximum ATTACK level, the comparitor inside goes into a DECAY phase which proceeds to the SUSTAIN level. The DECAY rate is set by the control voltage on pin 13 and the SUSTAIN level is set by the control voltage on pin 12. The exponential input is just like a typical oscillator input operating at approximately 18 millivolts per octave/time. The longest attack time is when U13B is at zero. The more negative this input becomes, the shorter the ATTACK. That time is cut in half for every 18 millivolt decrease.

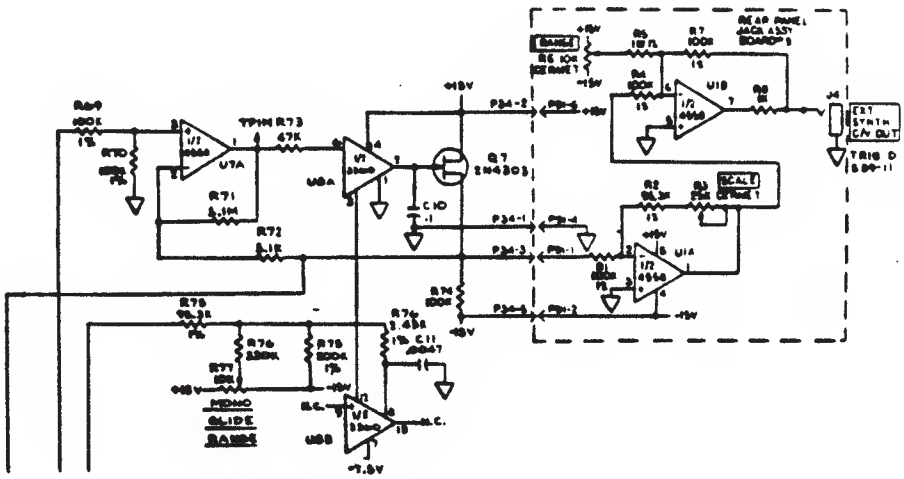
The SUSTAIN holds for as long as the gate is on. When the gate goes off, the VCA RELEASE phase starts. If the RELEASE switch is ON it will decay at the rate set by the RELEASE control voltage from the DMUX output. If the RELEASE switch is turned OFF, the computer tells the DMUX output to go to maximum which yields the fastest decay time. U18A is a 353 acting as a buffer for the sample/hold capacitor C27. The output of the 353 is fedback into the 3310 and this feedback loop creates exponential-type responses. The Envelope Generator is set by resistor R113 for the longest desired ATTACK time and all the Envelope Generators are similarly matched. The VCA output then has specific wires fed to individual VOICE CARDS.

FILTER CONTOURS

The FILTER Envelope Generator is configured like the LOUDNESS Contour Generator, except that there are two VCA's: one for the FILTER CONTOUR AMOUNT control and the second for VOICE MODULATION. VOICE MODULATION is fed to each individual VOICE CARD and is buffered.

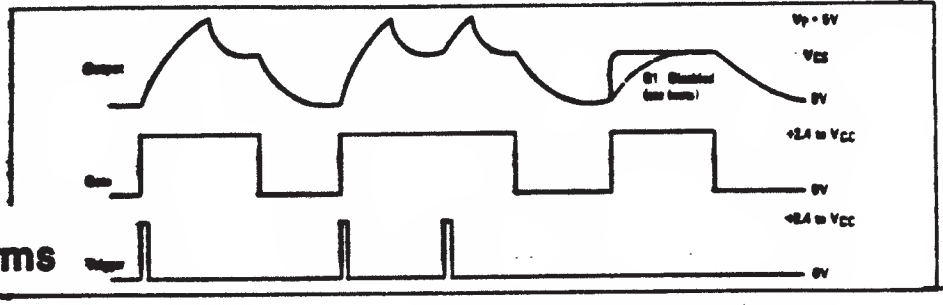
Looking back at the CONTOUR INPUTS, the UNCONDITIONAL ATTACK phase input is fed to a 393 U14A through a 74LS08 U15C. Whenever a trigger is received on any Envelope Generator during the ATTACK phase, pin 16 will drop slightly negative to about -1 volt. That will turn the output of the 393 on and couple it through the 74LS08 which is ANDED with the UNCONDITIONAL ATTACK. This trigger is basically on and operating and the 74LS08 keeps this 74LS32 OR gate on. In other words, when a key is pressed down, U15 turns on and turns the 74LS32 on which holds the trigger on. As soon as it ends the ATTACK phase, it jumps positive again, turns off and eliminates the trigger. If a note is still held down, a trigger will still exist but if the key is just "tapped", the ATTACK will begin and once completed it will go to the RELEASE phase.

The RETURN TO ZERO is accomplished with Q8 and Q9. The trigger input is differentiated by C25 and R116 and applied to the base of these transistors such that every time there is a trigger, it momentarily turns on the transistors and shorts C27 and C31. This means it will momentarily bring the contour down to ground. For the KEYBOARD FOLLOW, a bank of 4016s connects to each one of the CONTOUR GLIDE outputs. They are inverted and applied to the 3310 reference, pin 14, from which all the ATTACK, DECAY and RELEASE times are referenced. Therefore, changing the KEYBOARD VOLTAGE changes the reference voltage which, in turn, changes the apparent ATTACK, DECAY and RELEASE voltages which affects the time rate. Each one of the DMUX outputs is inverted for the ATTACK, DECAY and RELEASE time and is output to the VOICE CARDS on three-wire cables.



CEM 3310

Input and Output Waveforms



Voltage Controlled Envelope Generator

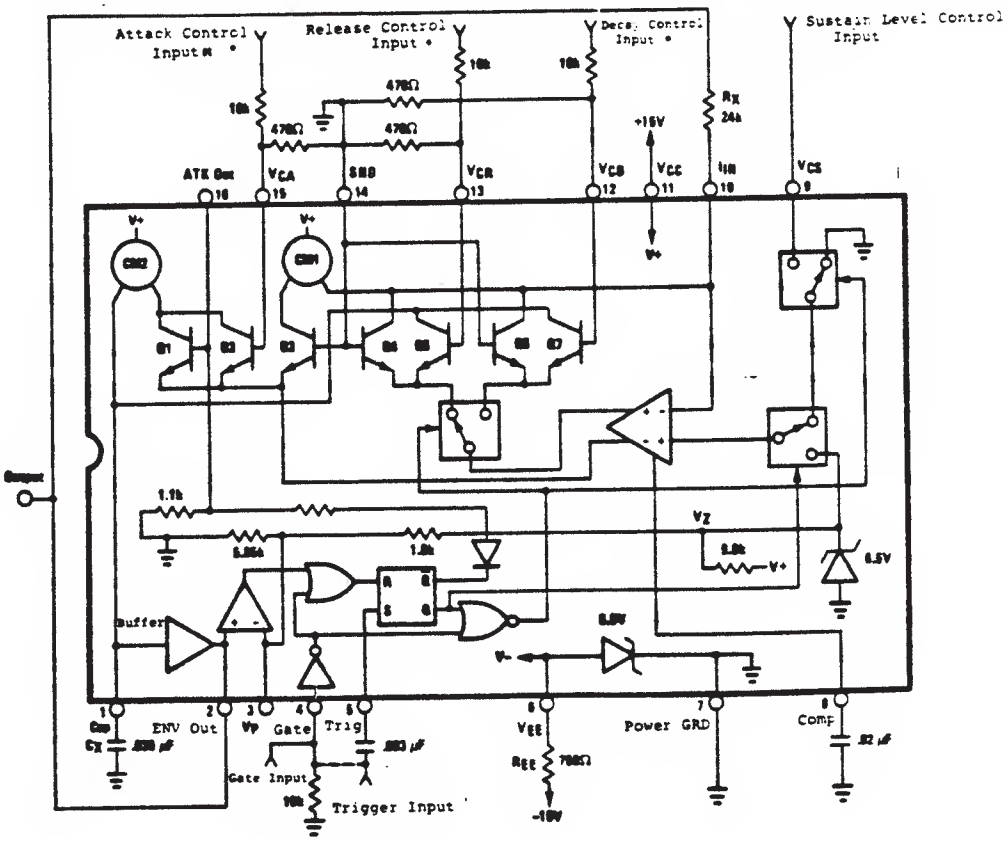
The CEM3310 is a self-contained, precision ADSR type of envelope generator intended for electronic music and other sound generation applications. Attack, decay and release times are exponentially voltage controllable over a wide range, and the sustain level is linearly voltage controllable from 0 to 100% of the peak voltage. A unique design approach allows for a 10,000 times improvement in control voltage rejection over conventional designs. In addition, much care has been given to the accuracy, repeatability and tracking of the parameters from unit to unit without external trimming. The times are to a first order determined only by the external resistor and capacitor and constant of physics, KT/q. Wide tolerance monolithic resistors are not used to set up the time constants or the control scale. Finally, all four control inputs are isolated from the rest of the circuitry so that the control pins of tracking units may be simply tied together. Although a low voltage process has been used to lower the cost and lower the leakage currents, an internal 6.5 volt Zener diode allows the chip to be powered by ± 15 volts supplies, as well as +15, -5 volt supplies.

* **Zero to -5V Varies the Times from 2mS to 20S**

** **Zero to +5V Varies the Sustain Level from 0 to 100%**

Absolute Maximum Ratings

Voltage Batween V_{CC} and V_{EE} Pins	24V
Voltage Between V_{CC} and Ground Pins	+18V
Voltage Between V_{EE} and Ground Pins	-6.0V
Current Into V_{EE} Pin	±50mA
Voltage Between Control and Ground Pins	±6.0V
Voltage to Gate and Trigger Input Pins	V_{EE} to V_{CC}
Storage Temperature Range	-55°C to +150°C
Operating Temperature Range	-25°C to +75°C



COMMON ANALOG BOARD #2

FOOT PEDAL CIRCUITRY

Starting at the upper left-hand corner of the schematic, analog control voltage from the rear panel FOOT PEDAL(s) is applied to U1A and U1B, the 3360 VCAs. FOOT PEDAL control AMOUNT is applied through the linear control inputs of the 3360 (pins 5 and 10 respectively) by a preprogrammed amount from the FRONT PANEL controls. The signal is buffered by a 4558 U2A&B and applied to a series of 4016 ENABLE switches driven from DEMUX board latches. Depending on what is selected from the FRONT PANEL switches, the FOOT PEDALS are programmed for PITCH, FILTER CUTOFF or VOLUME for FOOT PEDAL #1 and MODULATION or OSCILLATOR 2 for FOOT PEDAL #2. The FOOT PEDAL information is routed to MASTER OSCILLATOR SUMMERS.

The FOOT PEDALS are wired with normaling jacks such that a FOOT PEDAL in either input automatically routes it to the other. Therefore, one FOOT PEDAL can control all the functions of the instrument. If two FOOT PEDALS are plugged in, the functions are separated.

A ZERO and OFFSET trim eliminate the offsets of the 4558 and 3360 to avoid any pitch shift in the output. When the FOOT PEDALS are not used, a constant voltage is applied to the final VCA to turn it ON, thereby the MEMORYMOOG will always have an output. In addition, the software deactivates the VOLUME ENABLE from ever coming on, eliminating an owner trap. That is, if no FOOT PEDAL is inserted and the FRONT PANEL VOLUME push button is ON, the MEMORYMOOG would normally output a zero control voltage and the instrument would be "dead". However, this function is disabled in the software to make the unit trap free.

LHC CIRCUITRY (BOARD #10)

Below the FOOT PEDAL circuitry is the FRONT PANEL TUNE CONTROL, and the OCTAVE switch which mounts on the LEFT HAND CONTROLLER. These are summed through the 4016 switch U4A such that during AUTOTUNE these functions do not affect the pitch READ to the CPU. During normal operation, U4A is ON but during AUTOTUNE it is OFF to eliminate the TUNE and OCTAVE from affecting the AUTOTUNE frequencies.

The TUNE control is a standard divide down potentiometer and the OCTAVE circuitry is mounted on board #10. The OCTAVE has a dual 393 comparator hooked up as a SET/RESET flip-flop. When "-1" is depressed, it sends the output of U1A high and latches the output of U1B low, turning the latch ON. When the "-1" output goes high, it turns Q1 off and sends a voltage from U32 into the MASTER OSCILLATOR SUMMER to drop the oscillator summers one octave.

The PITCH WHEEL is also summed in through dead band diodes CR1 and CR2 and applied to VCA U5A. A programmed PITCH BEND AMOUNT of from one semitone to an octave is present from the program but can be overridden by the LEFT HAND CONTROLLER or FOOT PEDAL #1.

Next, there is a monophonic TRANSPOSE input from the DEMUX board that is originally generated on the CONTOUR/GLIDE board and is summed in turn, driving all the OSCILLATORS through the individual MASTER SUMMERS.

THE MODULATION OSCILLATOR

The 3340 U22 is the MODULATION OSCILLATOR which has a rate control input which is taken from the CPU. It also has a modulation RESET input for ARPEGGIATOR functions which is software controlled such that a note played on the keyboard when in the ARPEGGIATOR mode, develops a short spike. This spike goes to Q8 which momentarily shorts out the OSCILLATORS. It's like a "SYNC" input whereby the OSCILLATORS can be "RESYN'd" while playing to keep everything "in time". The outputs are connected conventionally with the TRIANGLE, SAWTOOTH, REVERSE SAWTOOTH (inverted by U23B) and PULSE outputs connected through a series of electronic switches to VCA U11B which controls the MODULATION AMOUNT.

The MODULATION AMOUNT is controlled by FOOT PEDAL #2 through switch U3D and either the LEFT HAND CONTROLLER MODULATION WHEEL or from the programmed FRONT PANEL MODULATION AMOUNT as provided from the DMUX board. Thus, for any particular program, the preset MODULATION AMOUNT may be overridden by the LEFT HAND CONTROLLER or FOOT PEDAL #2. All these modulation signals are summed together, routed to VCA U11B, buffered by the 741, U12, applied to another series of 4016 switches and ultimately applied to the MASTER SUMMERS for OSCILLATOR, PULSE WIDTH and FILTER CUTOFF.

S & H AND NOISE CIRCUITRY

Included in the MODULATION OSCILLATOR output to U11B is the SAMPLE AND HOLD and NOISE outputs. In the lower right hand corner, the output from the MODULATION OSCILLATOR PULSE is used as a sampling pulse for the SAMPLE AND HOLD. Also, located there is U25, a 5837 pseudo-random digital noise generator followed by a pink noise filter and gain recovery amp U26A. The pink noise output is fed to a 3360 VCA volume control which is buffered by a 4558 U26B and routed out the NOISE buss to all VOICE CARDS. The pink noise is also low pass filtered by R215 and C25 and routed to a 353 buffer U27B, into the SAMPLE AND HOLD circuit consisting of E112 FET Q7 and buffer U27A. The NOISE is sampled by a positive edge from the PULSE waveform and the output from U27A is connected to a 4016 switch U14B which then serves as another MODULATION source.

The control signals discussed above are now applied to the various MASTER SUMMERS for ultimate distribution to the six VOICE CARDS. It should be noted that FRONT PANEL CONTROL voltages are first digitized and then reconstructed to analog voltages again after processing by the CPU. This allows the use of the analog control values by the VOICE CARDS and storage of the digital value of these analog voltages by the CPU for reference and display purposes.

MASTER SUMMING CIRCUITS

In the top center of the schematic are U15, U16 and U17, 4558 inverters that sum inputs for OSCILLATORS 1, 2 and 3 respectively. Each one is followed by another inverter stage of the same IC. Each has OFFSET, OCTAVE and SUM adjustment trimmers. All OSCILLATORS sum PITCH, OCTAVE, MONOPHONIC MODULATION AND TRANSPOSE and then uniquely sum specialized functions like OSCILLATOR 2 FREQUENCY, OSCILLATOR 3 FREQUENCY, etc. The LOW FREQUENCY/KEYBOARD CONTROL, for example, is a special control input for OSCILLATOR 3 which increases its range from +/- one octave to +/-2.5 octaves whenever OSCILLATOR 3 is used in the VOICE MODULATION mode.

Similarly, to the right of the MASTER OSCILLATOR SUMMERS are the MASTER PULSE WIDTH SUMMERS which sum pulse width control voltages. Still further to the right is the MASTER FILTER SUMMER which sums the FRONT PANEL FILTER CONTROL, the FILTER MODULATION PITCH and CUTOFF OUTPUTS.

MONOPHONIC/POLYPHONIC FUNCTIONS

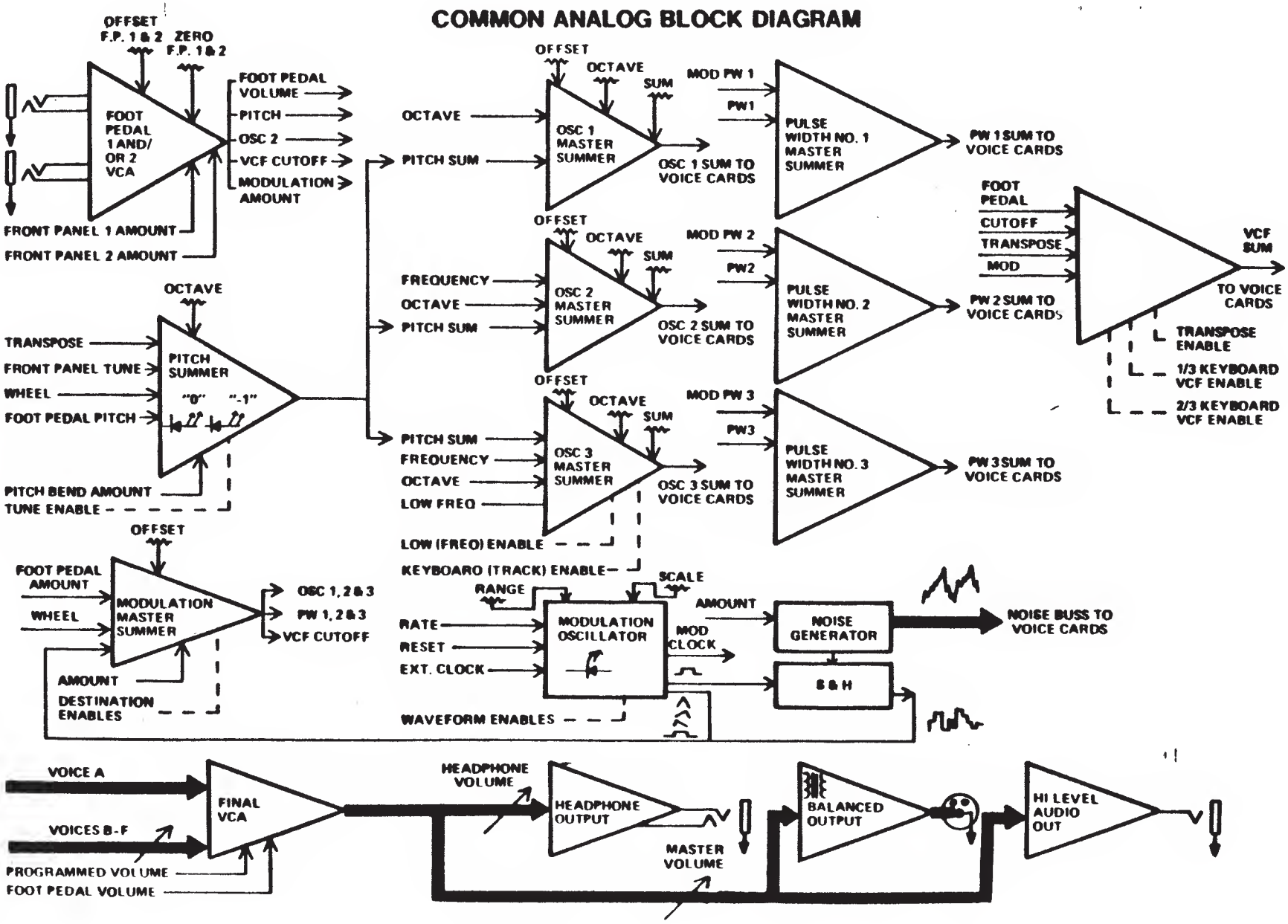
The MEMORYMOOG can be operated as a six voice polyphonic or a monophonic synthesizer which means between one and six VOICE CARDS can be selected to track the keyboard. Furthermore, in the HOLD mode, an entire chord can be transposed when a new single note is played. Thus, there is a need for the keyboard to output six independent drives for the VOICE CARDS for POLYPHONIC operation and a MASTER signal to drive all VOICE CARDS simultaneously for MONOPHONIC operation. In addition, there are certain applications where it is desirable for the FILTER to track a voltage proportional to the monophonic keyboard voltage.

Switches U28C&D provide the monophonic keyboard voltage when in the MONOPHONIC mode and turn ON while the normal VOICE CARD switches are turned OFF. This provides a common keyboard tracking signal to all VOICE CARDS. Zener diodes CR10 and CR11 level translate the FILTER ENABLE signal from zero to 15 volts down to +/- 7.5 volts for use by the 4016 switches.

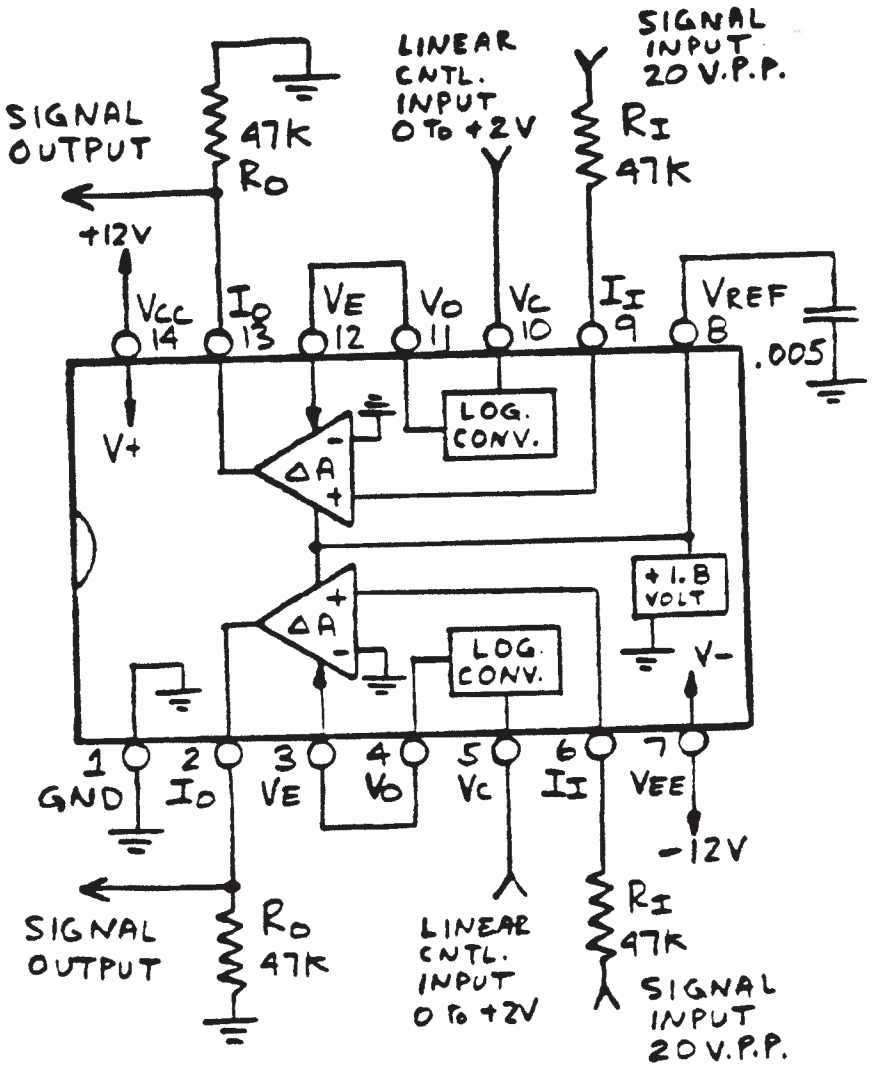
THE AUDIO OUTPUT

At the lower left hand corner, the audio output from each VOICE CARD is summed together. Notice that VOICES B through F have individual trim pots to match the output VOLUME of each VOICE CARD to the A VOICE. The output is summed into a 3360 VCA which has a programmable output signal from the DMUX board such that a preset volume can be established for different programs. Therefore, FILTER CUTOFF variations can be compensated for with PROGRAMMED VOLUME levels. The output of the VCA is routed to U6B, another VCA which is for FOOT PEDAL override. This, in turn, is applied to a 353 buffer U7B, the output of which is routed to the MASTER VOLUME control on the FRONT PANEL. It returns through shielded cable to U7A, a 353 buffer, and next is applied to the unbalanced high level AUDIO OUTPUT. In turn, the audio is connected to T1, an interstage transformer which provides a BALANCED OUTPUT. The signal is also applied to the HEADPHONE VOLUME control through an LM386 and finally to the HEADPHONE output jack. The 386 IC must be powered at less than 15 volts, therefore the 15 volts is dropped to 11 volts through Q2.

COMMON ANALOG BLOCK DIAGRAM



V.C.A.



CEM3360 BLOCK DIAGRAM AND TYPICAL CONNECTION

DISASSEMBLY AND REASSEMBLY

(Refer to the Accompanying Photographs and Diagrams)

REMOVING THE BASE

With the unit right side up on the workbench and the keyboard facing away, remove the three (3) self-tapping sheet metal screws on the rear panel. Remove the nine (9) self-tapping sheet metal screws, three (3) on either side, three (3) along the front of the base, by letting the edge of the unit hang over the end of the bench. Separate the cabinet from the base, making sure to clear the front edge of the keyboard. Lean the cabinet back onto its rear panel.

NOTE: Do not attempt to remove screws from base of unit by turning unit upside down as damage to front panel controls may result.

CAUTION - KEYBOARD PROTECTION

Before proceeding with further disassembly or servicing, care should be taken to protect keyboard from:
-Scratches from solder spikes of printed circuit boards.
-Chemical reaction of special cleaners or sprays to the plastic key parts.
It is suggested that the keyboard be covered with a piece of soft foam or similar protective material during repair.

CONNECTOR REMOVAL

Virtually all connections to the PC board are made with either CIS, MTA or RIBBON CABLE connectors. If it is necessary to remove any of these connectors during troubleshooting, do so by grasping the connector housing firmly and lifting upward. In the case of the CIS and MTA connectors, NEVER PULL ON THE WIRES. Remove the ribbon connector as you would an IC, by inserting a small screwdriver between the pins and prying with slight pressure. NEVER REMOVE A CONNECTOR FROM ITS SOCKET BY PULLING ON THE RIBBON CABLE.

REMOVING THE CONTOUR BOARD

To remove the CONTOUR BOARD, the keyboard must first be removed (see KEYBOARD REMOVAL). With keyboard removed, locate the PC board mounting posts and lift the board up while slightly bending on the locking tab.

REMOVING THE DIGITAL BOARD

The DIGITAL BOARD is held in by four (4) screws. The rear screws attach the board to hinged standoffs. The DIGITAL BOARD is also attached by a tie-wrap to the COMMON ANALOG BOARD. Note the use of insulation (fish paper) on the trace side of the board.

REMOVING THE COMMON ANALOG BOARD

The COMMON ANALOG BOARD is held in by four (4) screws. The rear screws attach the board to hinged standoffs. The COMMON ANALOG BOARD is also attached by a tie-wrap to the DIGITAL BOARD. Note the use of insulation (fish paper) on the trace side of the board.

REMOVING DMUX BOARD

The DMUX BOARD is mounted below the DIGITAL and COMMON ANALOG BOARDS using four (4) standoffs. These two (2) boards must be removed to remove the DMUX BOARD.

If problem is isolated to the DMUX BOARD, components on this board may be replaced by removing the eight (8) mounting screws from the base and removing the entire three (3) board assembly as a unit.

REMOVING VOICE CARDS

There are six (6) VOICE CARDS mounted in a three layer "sandwich" formation. The two (2) top right-hand boards (VOICE CARDS A & B) are mounted back-to-back with the center two (2) boards (VOICE CARDS C & D) using four (4) screws. The two (2) rear screws attach the four (4) boards to hinged standoffs, spacers and fish paper.

VOICE CARDS E & F are mounted to the base of the unit. The top four (4) VOICE CARDS must be removed in order to remove these two (2) VOICE CARDS. VOICE CARD E is located at the center and VOICE CARD F is loaced on the right-hand side.

If a problem is isolated to either VOICE CARD E or F, components on these boards may be replaced by removing the eight (8) mounting screws from the base and removing entire six (6) board assembly.

REMOVING THE POWER SUPPLY

The POWER SUPPLY is attached to the rear panel with six (6) screws, four (4) of which are accessible from the rear of the unit and two (2) are accessible from the inside below the POWER SUPPLY PC board. Once the mounting screws are removed, remove the four (4) connectors and slip the subassembly out through the rear panel.

Troubleshooting of the POWER SUPPLY may be accomplished by placing it atop the DIGITAL/COMMON ANALOG BOARDS under a suitable insulating material.

REMOVING FRONT PANEL

LEFT SIDE CONTROL BOARD (LSC)

It is recommended, for ease of service, to remove the POWER SUPPLY (See POWER SUPPLY removal) before attempting the removal of the LSC. Once the CONTROL BOARD is removed, it may be placed on the DIGITAL BOARD/COMMON ANALOG assembly using a cardboard separator or similar material. The POWER SUPPLY may temporarily be reinstalled for unit servicing using the two (2) inside screws.

To remove the LSC board, remove the control knobs and the eleven 5/16" hex nuts, taking note of four (4) fiber washers used on earlier versions (approximately S/N 1400 and below).

RIGHT SIDE CONTROL BOARD (RSC)

This is accomplished by removing the control knobs. The FREQUENCY CONTROL for OSCILLATOR 2 and OSCILLATOR 3 requires a .050 and a 1/16" hex key wrench. Remove the twelve (12) 5/16" hex nuts.

NOTE: The LEFT and RIGHT SIDE CONTROL BOARDS are electrically connected together using two (2) ribbon cables. When reinstalling these boards make sure these cables lay flat against the PC board so as not to obstruct switch action.

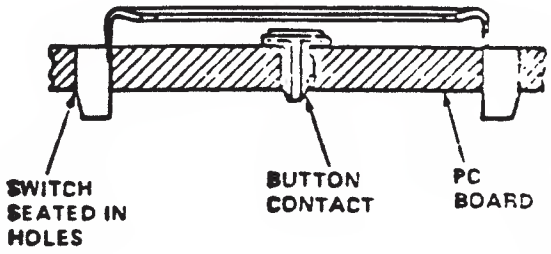
SWITCH REMOVAL

The switch assembly is made up of four (4) components: the spring contact which is shown mounted on the PC board & soldered in place, the switch contact button (not shown in photo), the switch button or acutaor, e.g. "D" and the return spring. The plastic button may be removed by using the handle end of a screwdriver and pressing it on the two (2) stems that protrude through the PC board. When reinstalling the button use slight pressure to push the two (2) stems through the PC board insuring the spring is seated correctly and does not short against the switch contacts.

SWITCH CONTACT REPLACEMENT

If it is necessary to replace a spring contact switch or a contact button, extreme care must be taken when installing the new components.

The contact button is replaced by first removing the switch contact, then the contact button. The contact button must be seated against the PC board. The contact button may also be inserted using an AMP hand tool, model number 274262-1. The spring contact may be replaced using AMP tool number 274268-1 or by hand. When inserting by hand, use extreme caution and lightly press on each side-mounting pin of the contact until it is through the PC board. NEVER push the contact into the PC board by pressing on the CENTER of the spring contact as this will misshape it. Note the accompanying insertion diagram.

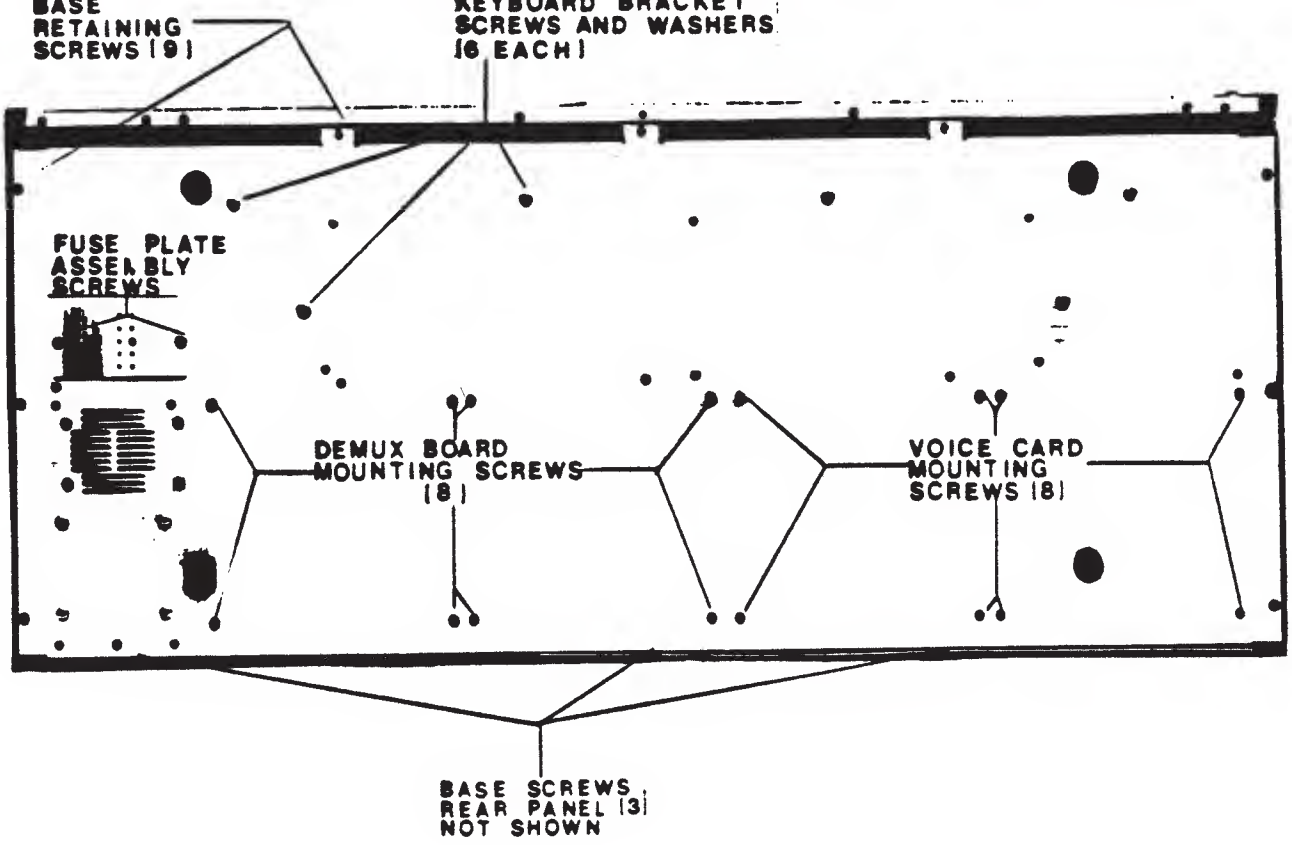


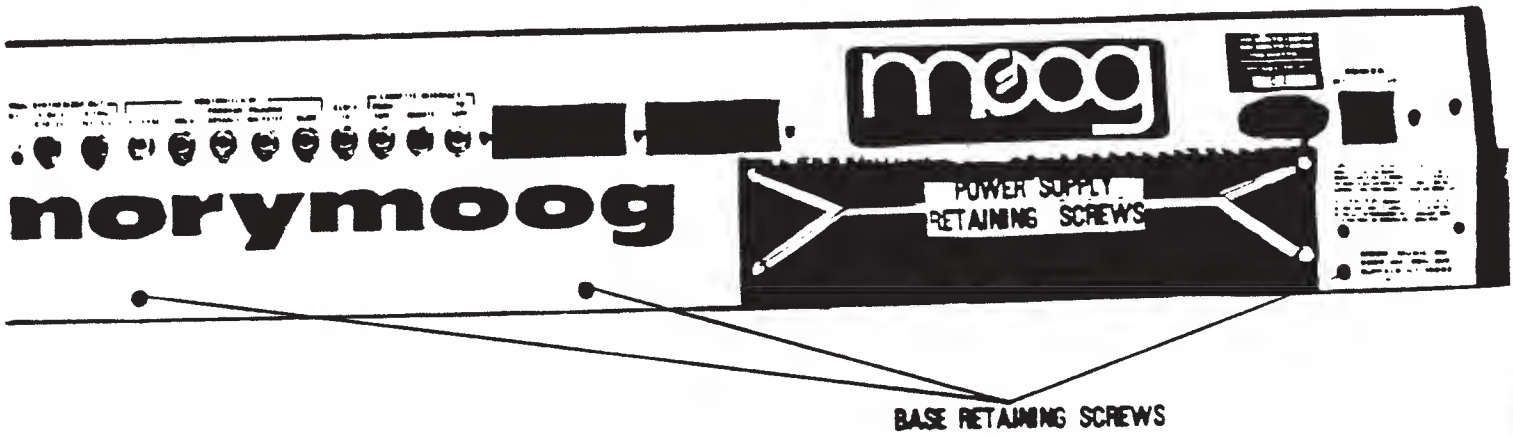
REMOVING THE KEYBOARD

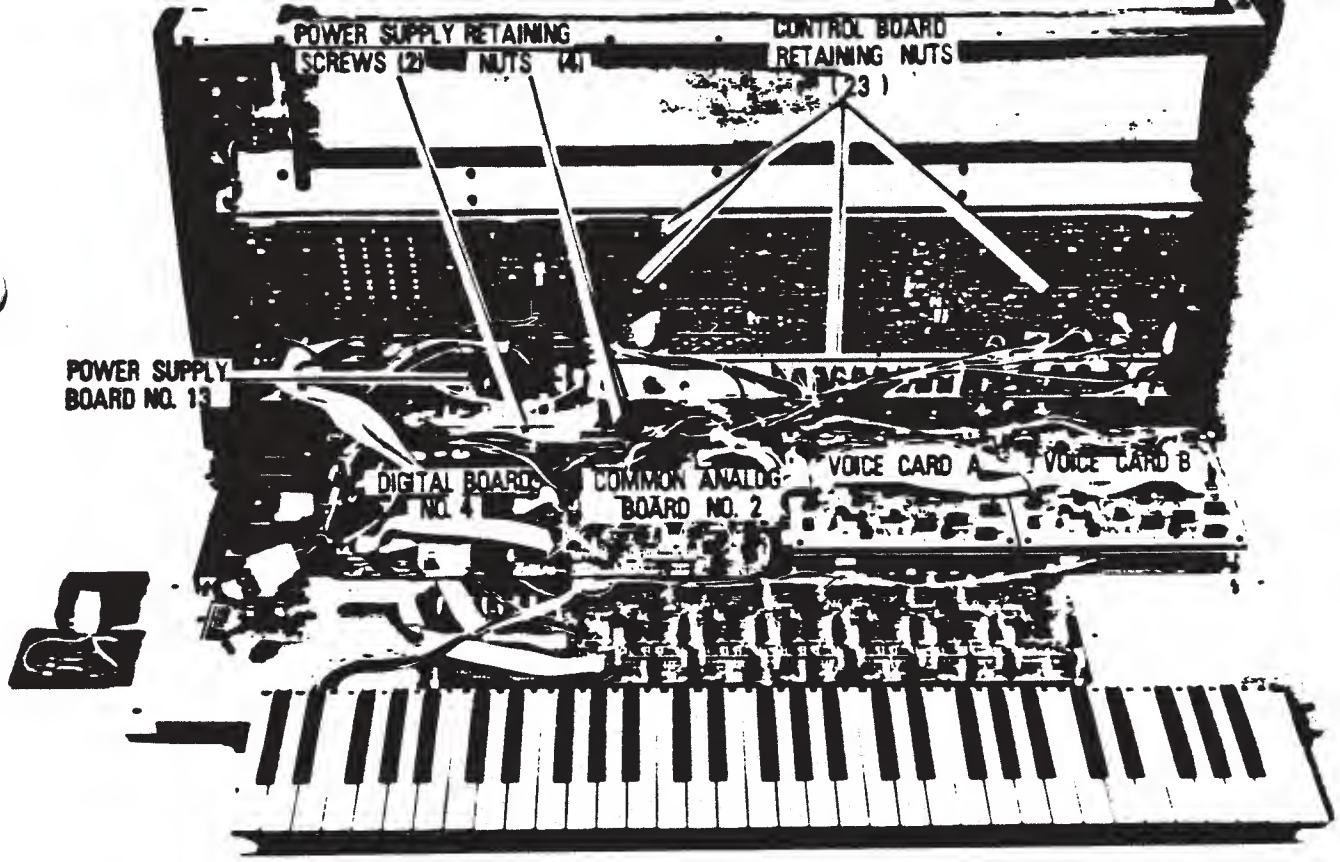
The keyboard is secured with six (6) screws accessible from the underside of the unit. The connector at the left rear of the keyboard assembly may also be disconnected for complete removal of the keyboard.

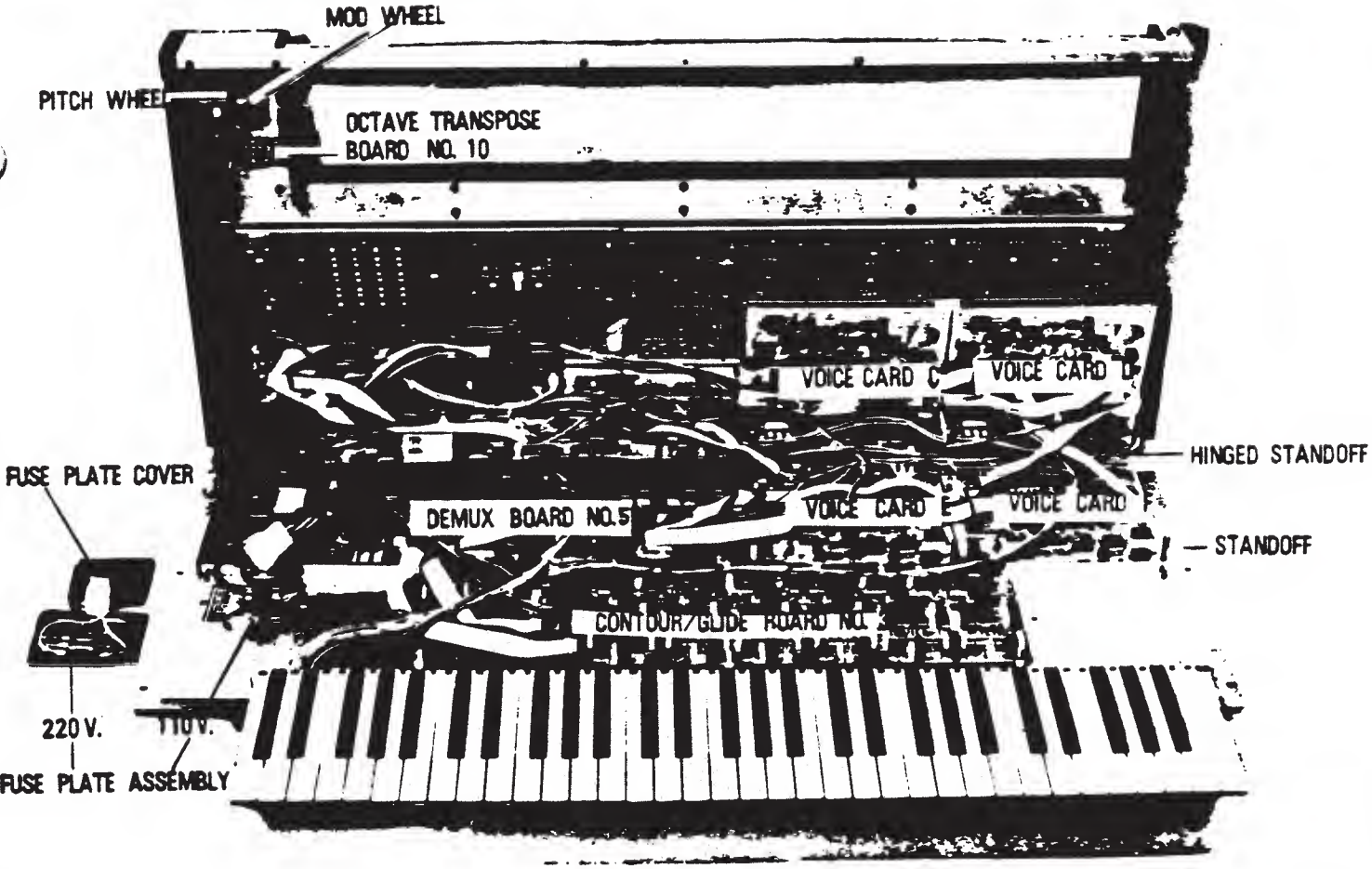
KEY REMOVAL

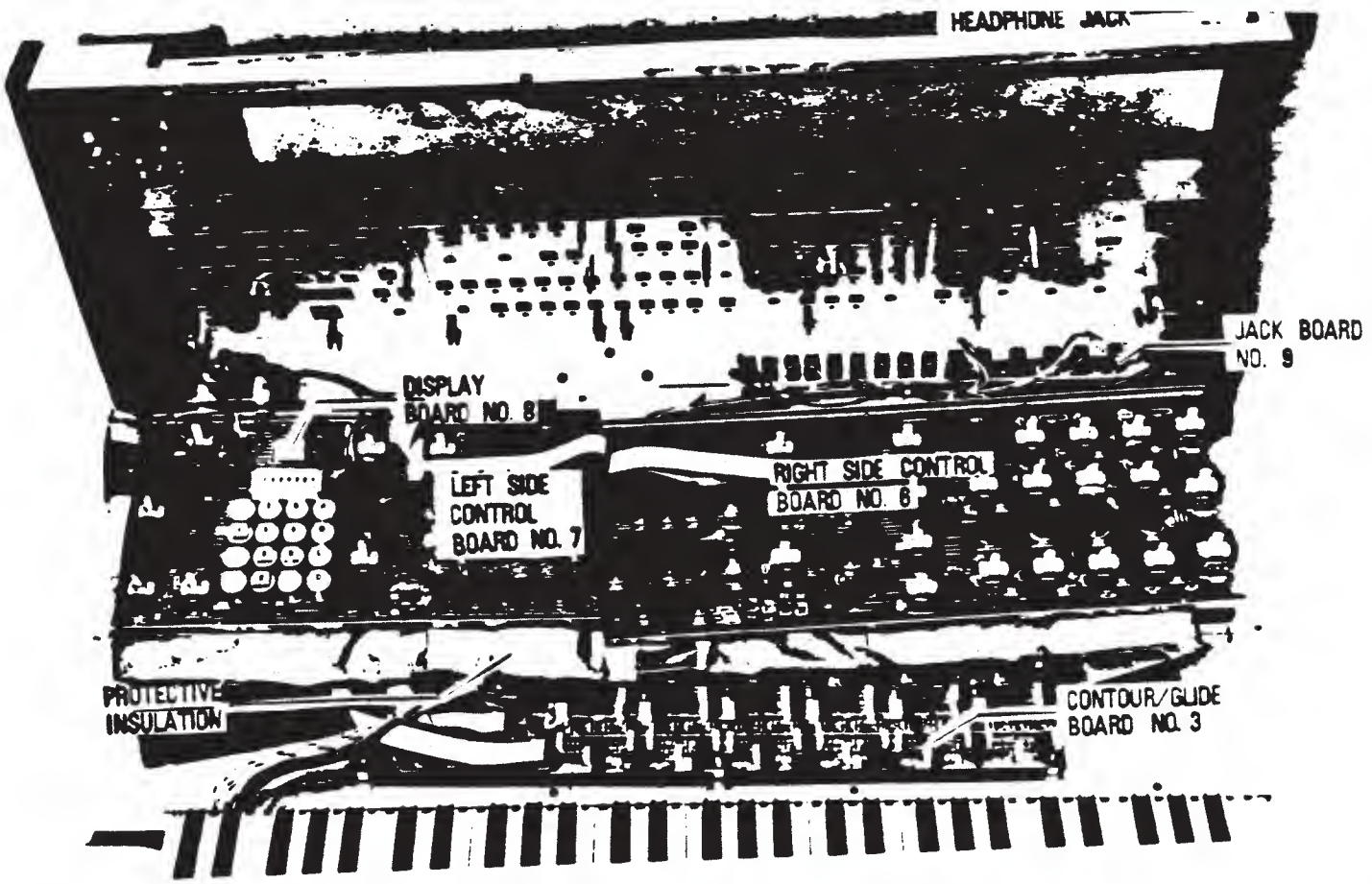
While holding the front end of the key and applying slight pressure to rear of the key, disengage the notches from keyboard frame noting that the key is held in not only by the notches but also by side pressure against the frame.

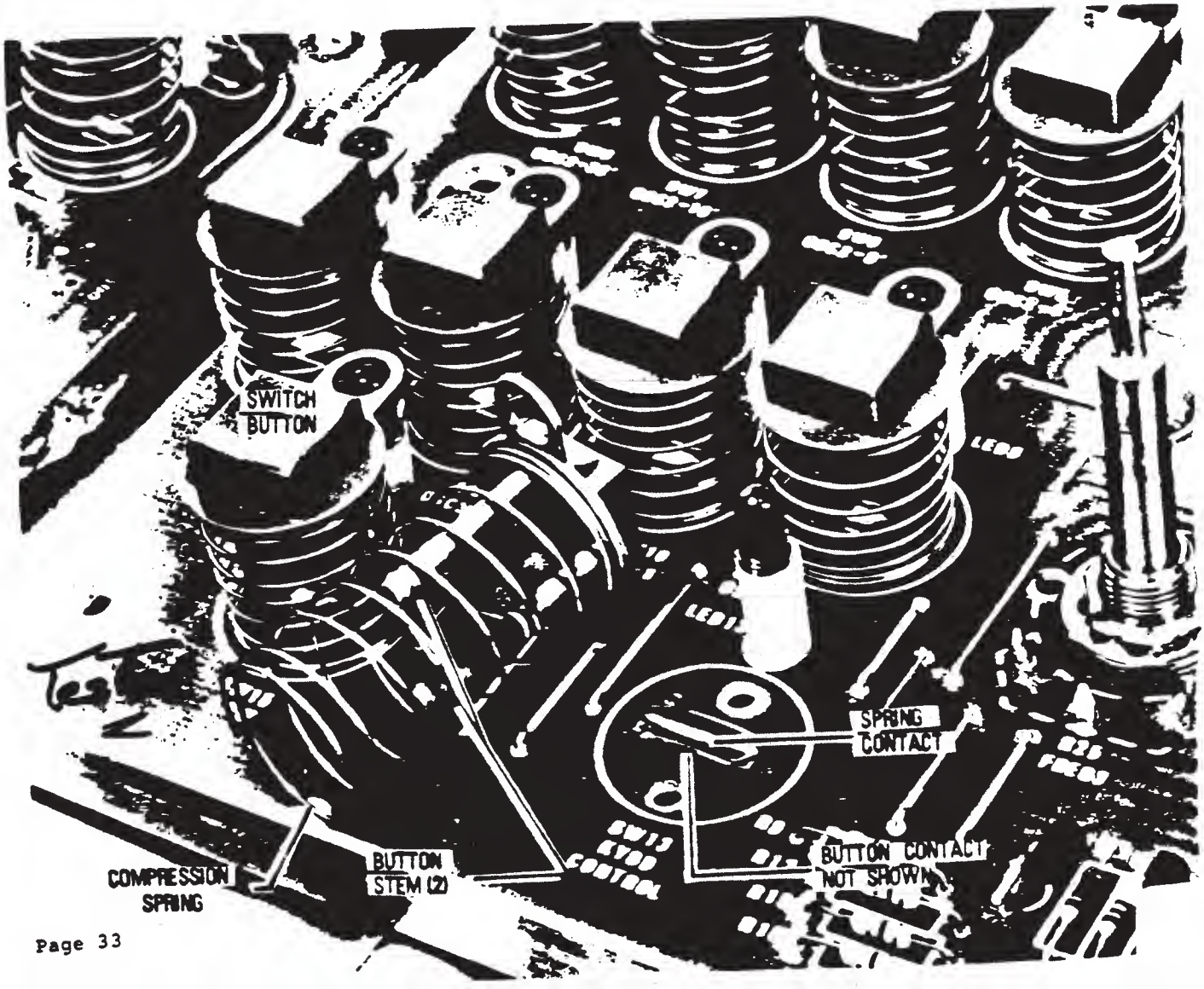

BASE
RETAINING
SCREWS (9)
KEYBOARD BRACKET
SCREWS AND WASHERS
(6 EACH)
FUSE PLATE
ASSEMBLY
SCREWS
DEMUX BOARD
MOUNTING SCREWS
(8)
VOICE CARD
MOUNTING
SCREWS (8)
BASE SCREWS,
REAR PANEL (3)
NOT SHOWN

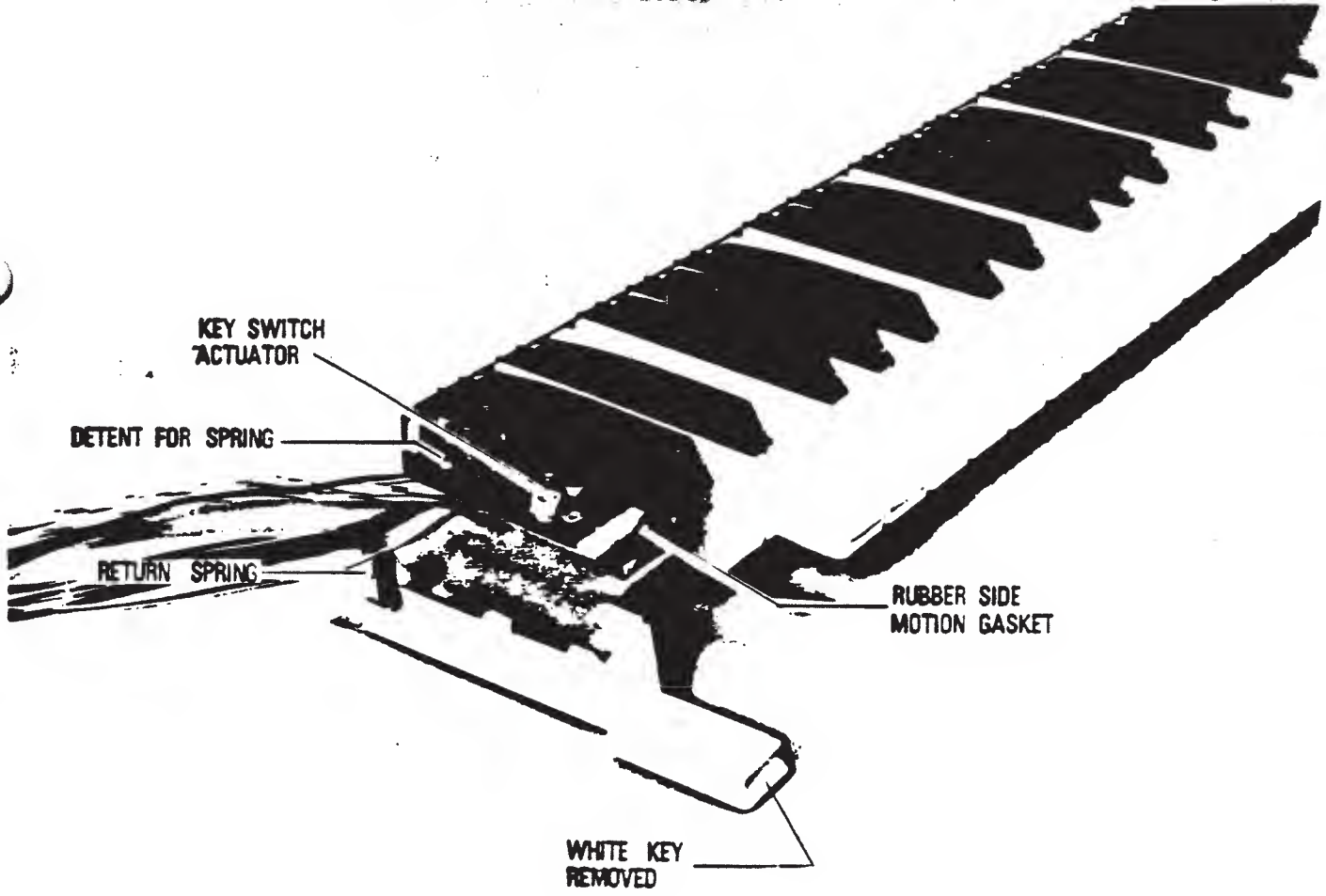

moog
norymoog
POWER SUPPLY
RETAINING SCREWS
BASE RETAINING SCREWS

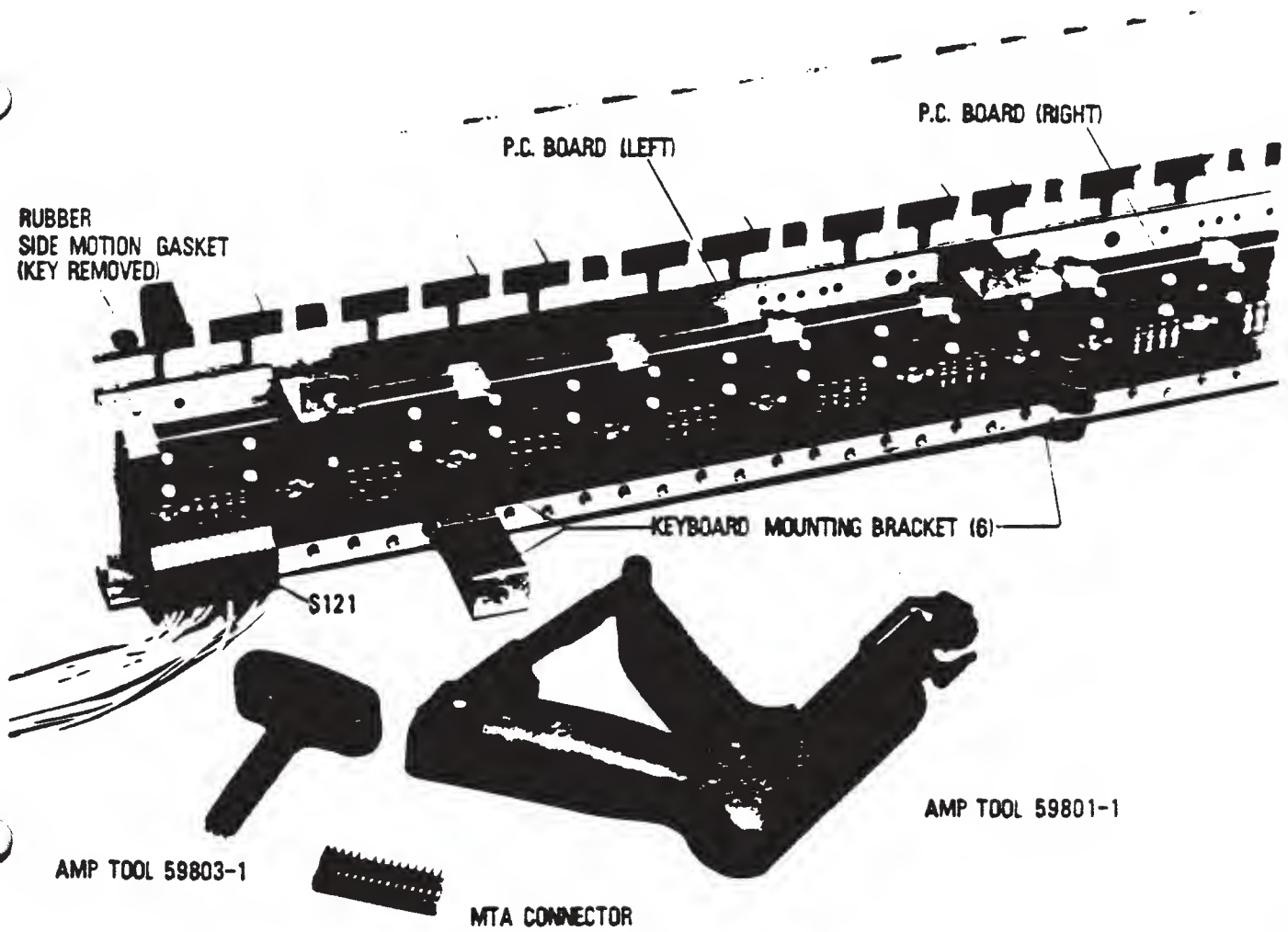

POWER SUPPLY RETAINING SCREWS (2)
NUTS (4)
CONTROL BOARD RETAINING NUTS (23)
POWER SUPPLY BOARD NO. 13
DIGITAL BOARD NO. 4
COMMON ANALOG BOARD NO. 2
VOICE CARD A
VOICE CARD B


MOD WHEEL
PITCH WHEEL
OCTAVE TRANSPOSE BOARD NO. 10
VOICE CARD C
VOICE CARD D
HINGED STANDOFF
FUSE PLATE COVER
DEMUX BOARD NO.5
VOICE CARD E
VOICE CARD F
STANDOFF
CONTOUR/GLIDE BOARD NO.
220 V.
110V.
FUSE PLATE ASSEMBLY


HEADPHONE JACK
JACK BOARD NO. 9
DISPLAY BOARD NO. 8
LEFT SIDE CONTROL BOARD NO. 7
RIGHT SIDE CONTROL BOARD NO. 6
PROTECTIVE INSULATION
CONTOUR/GLIDE BOARD NO. 3


SWITCH BUTTON
LED3
LED1
SPRING CONTACT
LED2
COMPRESSION SPRING
BUTTON STEM (2)
BUTTON CONTACT NOT SHOWN


KEY SWITCH
ACTUATOR
DETENT FOR SPRING
RETURN SPRING
RUBBER SIDE
MOTION GASKET
WHITE KEY
REMOVED


P.C. BOARD (RIGHT)
P.C. BOARD (LEFT)
RUBBER
SIDE MOTION GASKET
(KEY REMOVED)
KEYBOARD MOUNTING BRACKET (6)
S121
AMP TOOL 59801-1
AMP TOOL 59803-1
MTA CONNECTOR

TROUBLESHOOTING

GENERAL

Many synthesizer repairs involve the replacement of integrated circuits. However, before replacing a suspect device, always double check the inputs and power supply terminals before proceeding. For any devices that are installed in sockets, thoroughly check each device for a possible "bent under" pin on the IC before proceeding with detailed troubleshooting of the circuit.

LINEAR IC

A linear IC with DC Input Offset measured between the + and - inputs should be no greater than 10mV apart or device is faulty.

Note in the accompanying diagram a typical IC used in a linear mode with negative feedback.

CMOS IC's usually fail by latching the output(s) and getting hot to the touch.

OTA

Pin 5 of a 3080 type OTA should be 0.7V more positive than pin 4 when turned on. Troubleshoot it like a forward biased diode.

Use the charts provided on the following pages along with the circuit description and block diagrams to partition a problem, then, using the schematics and parts location information on the PC boards, final diagnosis and repair can be effected.

Once it is determined that an IC must be replaced, install the new one in a high quality IC socket. This will protect the printed circuit board in case further troubleshooting is necessary. Sometimes an IC known to be good can be used from another circuit to confirm a suspected problem.

****

NOTE: If the old IC is found to be good, put the old one back in. The old IC has more time in use and is therefore more reliable than a new IC of unknown performance.

****

Many faulty or shorted ICs will operate "hot" and can be detected with the "wet finger test".

POWER SUPPLY SUBASSEMBLY GENERAL SERVICING

The -15, +15 and +5 VDC outputs of the power supply subassembly must be checked first and adjusted to their nominal values within 10 millivolts prior to any equipment servicing. The most common anticipated problems related to the power supply subassembly are open recitifier diodes and transistors.

POWER SUPPLY SUBASSEMBLY TROUBLESHOOTING

Troubleshoot the power supply subassembly using the circuit description. Note that voltage levels displayed on the schematic diagrams are not absolute values as readings may vary between units. Once the problem is localized, check the suspected part by direct substitution if possible. Otherwise, use a voltmeter or oscilloscope to determine the malfunctioning part. Note the color code on the power supply schematics: +15V (red), -15V (black), +5V (yellow), ground (green).

CONNECTOR REPAIR AND REPLACEMENT

There are two basic types of connectors in the MEMORYMOOG synthesizer made by AMP. The first type is the Mass Termination Assembly (MTA) insulation displacement type connector.

The MTA 100 Series connector is based on .1 inch mounting centers pin spacing and is also color coded for a wire gauge. The red series MTA connectors in the MEMORYMOOG are to be used with only 22 gauge wire.

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CAUTION

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When disconnecting an MTA connector from a printed circuit board, be sure to firmly grip only the "connector housing" - NEVER disconnect it by pulling on the wire(s).

==========

In order to properly repair an MTA connector in the field it should be replaced. First remove the old contact from the housing by poking a solder pick into the side "ramp" thereby freeing the contact. Next, install a new contact into the housing, cut off any damaged portion of the wire and proceed as follows:

1. Use an AMP pistol insertion tool model 59801-1 and insert the housing from the left side. Placing the wire in the contact, secure it by tightening the tool handle or
2. Mount the housing into a heavy vise, insert the wire and press firmly into place by using the AMP hand tool, model 59803-1.

The second type of connector is the Commercial Interconnection System (C.I.S.) crimp socket which has 0.1 inch (2.5mm) mounting centers. This is a reliable connection system which can easily be replaced if necessary. The portion of the connector attached to the printed circuit board (header) is replaced by simply soldering a new one in place. Headers of 5, 6 or more pins can easily be cut using wire cutters to replace 1, 2, 3 or 4 pin versions. Simply score the header where the desired cut is to be made and cut the header appropriately. Refer to the accompanying illustrations.

Headers which are causing poor or intermittent solder connections on a printed circuit board should be resoldered to ensure the best possible electrical and mechanical connection. If connector plating problems are suspected, use an extra activated multicore solder such as 0.064 diameter ERSIN No. 782/745 solder and a 40 watt soldering iron.

NOTE: BE SURE TO AVOID LONG EXPOSURE OF THE IRON TO THE PRINTED CIRCUIT BOARD TRACES AND TO CLEAN THE ACTIVATED FLUX RESIDUE FROM THE PRINTED CIRCUIT BOARD AFTER SOLDERING IS COMPLETE. RECOMMENDED FLUX CLEANER IS MILLER-STEPHENSON MS-190HD, "HEAVY DUTY FLUX REMOVER" OR A METHYL ETHYL KEYTONE PRODUCT.

Replacement of the female C.I.S. connector terminal is sometimes necessitated if a wire breaks at the crimp within the socket. The spring loaded terminal may be removed using an AMP Extracting Tool, AMP Part No. 457445-1A or by inserting two pointed instruments into each side of the socket allowing a particular terminal to be pulled out or pushed out using an existing header pin or 1/4 watt resistor lead. The new terminal may be attached to the wire by using an AMP Hand Crimping Tool, AMP Part No. 90062, or by cutting the tabs off the new terminal and tack soldering it to the appropriate wire which has been stripped back 5/32 inch (3.9mm). The soldering must be neat and flattened with needle-nose pliers to ensure an easy fit into the connector housing.

KEYBOARD AND CASE MAINTENANCE

To clean the wood end caps, the aluminum chassis and front panel overlays, a damp cloth with a mild detergent is sufficient.

The keyboard may also be cleaned by using a damp cloth and mild detergent. However, if there is light dirt or scratch marks on keys, hand rubbing with a fine polishing compound works best. For deeper scratch marks or ground-in dirt, a variable high speed drill with cloth buffing wheel is recommended. The buffing wheel should be used carefully with a small amount of fine polishing compound. Be sure to use light pressure as heavy pressure or long exposure to one area will cause the plastic keys to melt or warp due to friction.

The conductive rubber style keyboard requires no maintenance and if contaminated with a foreign substance spilled into the mechanism, it should be replaced in its entirety. Refer to disassembly section for key cap replacement.

POWER SUPPLY TROUBLESHOOTING GUIDE

SYMPTOM	CAUSE/REMEDY
1. Apply primary power to MEMORYMOOG and connect voltmeter negative test lead to "-" side of C74 on DMUX board and and positive test lead to "+" side of C74. Observe digital voltmeter and adjust +15 VDC trim pot R19 on power supply assembly for +15 VDC +/-10mv.	If proper voltage is present proceed to step 2. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 7 (+) and 9 (-). If present, perform step 4. If not present, trouble is in power supply assembly.
2. Connect positive test lead to "+" side of C73 on DMUX board. Observe digital voltmeter and adjust +5 VDC trim pot R33 on power supply assembly for +5 VDC +/-10 mv.	If proper voltage is present, proceed to step 3. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 14 (+) and 12 (-). If present, perform step 4. If not present, trouble is in power supply assembly.
3. Connect positive lead to "-" side of C75 on DMUX board. Observe digital voltmeter and adjust -15 VCD trim pot R8 on power supply assembly for -15 VDC +/-10mv.	If proper voltage is present, power supply assembly is operating properly. If output voltage is not present or cannot be adjusted disconnect power supply output connector and measure voltage between pins 4 (-) and 2 (+). If present, perform step 4. If not present, trouble is in power supply assembly.
4. Reconnect power supply output connector and digital voltmeter test leads to pins on DMUX BOARD where proper voltage was not available.	Monitor digital voltmeter sequentially disconnect power supply input connectors on the printed circuit boards until voltage indication appears (shorted board located). Troubleshoot or repair board as outlined in the applicable section. If voltage indication still is not present, trouble is in cable harness.
5. Loss of all output voltages.	Power source, power cord, power switch, fuses and T1.

6. -15 VOLT SUPPLY - Loss of -15V output voltage.	Voltage buss external to power supply shorted to common, P132, CR1 thru CR4, Q1, Q2, IC1, R8, P131 and C3.
Voltage at pin 6 of IC1 is not -7.85 +/-0.39V or voltage at pin 10 is less than -1.62V.	IC1, C1, R2 thru R4, R6 and and R10.
Loss of -15V output adjustment.	R10, R7 thru R9.
Excessive -15V output voltage, no voltage control.	Q1, Q2 and IC1.
Low -15V output voltage.	CR1 thru CR4, instrument wiring shorted (power supply in current limiting).
7. +15 VOLT SUPPLY Loss of +15V output voltage.	Voltage buss external to power supply shorted to common, P133, CR8 thru CR11, Q3, Q4, IC2, R19, P131 and C6.
Voltage at pin 6 of IC2 is not +7.15 +/-0.36V or voltage at pin 10 is less than +16.7V.	IC2, C4, R13 thru R15, R17, R21, CR12 and C6.
Loss of +15V output adjustment.	R18 thru R21.
Excessive +15V output voltage, no voltage control.	Q3, Q4 and IC2.
Low +15V output voltage.	CR8 thru CR11, instrument wiring shorted (power supply in current limiting).
8. +5 VOLT SUPPLY Loss of +5V output voltage.	Voltage buss external to power supply shorted to common, P3, CR15 thru CR18, Q5 thru Q7, IC3, R33, P4 and P9.
Voltage at pin 6 of IC3 is not +7.15 +/-0.36V or voltage at pin 10 is less than +7.32V.	IC3, C7, R35, R24 thru R28, R30, R31, CR19 and C9.
Loss of +5V output adjustment.	R33 thru R35.
Excessive +5V output voltage, no voltage control.	Q5 thru Q7 and IC3.
Low +5V output voltage.	CR15 thru CR18, instrument wiring shorted (power supply in current limiting).

VOICE CARD TROUBLESHOOTING GUIDE

The MEMORYMOOG has a software routine to isolate defective VOICE CARD OSCILLATORS. Depress the AUTOTUNE button and observe the display. In 5 to 10 seconds, the display will show "X tuned", where X is the number of usable voices. X will equal 6 if all VOICE CARDS are good. If X is less than 6, faulty VOICES can be isolated as follows:

1. Depress "C7" followed by "ENTER" twice.
2. The display will show "VOICE ?".
3. Depress any VOICE number (1 through 6) desired to be tested, where VOICE A = 1, VOICE B = 2, etc.
4. After about 1 second the display will show "OSC ?".
5. Depress any oscillator number (1 through 3) desired to be tested.
6. One of the following will be shown on the display in a flashing format:
   "DEAD OSC", which is self-explanatory, or the letters "XX", "YY" or "ZZ". "XX", "YY", "ZZ"are 2-digit hexidecimal numbers indicating the AUTOTUNE voltages for the OSCILLATOR. Nominal values of 7F hex would indicate all three oscillators are close in value to each other but a 00 or FF display for one or more of the three numbers indicates the oscillator(s) cannot be AUTOTUNED and must be recalibrated.
7. Depress ENTER twice to continue testing as in Step A2 for other VOICES and/or OSCILLATORS. Entering an invalid number for a VOICE >6 or OSCILLATOR >3 will exit this testing mode.

INDIVIDUAL VOICE CARD TROUBLESHOOTING

SYMPTOM	CAUSE/REMEDY
1. One of the three OSCILLATORS is dead, or waveforms are missing.	Check for 10 volt waveforms (PULSE, SAWTOOTH, TRIANGLE) at: Osc. 1,U3 (4016) Pins 1,4 & 8 Osc. 2,U7 (4016) Pins 1,4 & 8 Osc. 3,U10(4016) Pins 1,4 & 8
2. NO waveforms present from Step 1.	Faulty (3340) VCO or (4558) Osc. 1, U1(3340), U2 (4558) Osc. 2, U5(3340), U6 (4558) Osc. 3, U8(3340), U9 (4558)
3. ALL waveforms present from STEP 1.	Check for proper switching of the waveforms (PULSE, SAW-TOOTH, TRIANGLE) at: Osc. 1,U3 (4016) Pins 2,3 & 9 Osc. 2,U7 (4016) Pins 2,3 & 9 Osc. 3,U10(4016) Pins 2,3 & 9 Use the FRONT PANEL WAVEFORM switches to enable the individual waveforms & proceed to Step 5.
4. TRIANGLE waveform and/or PULSE wave missing from STEP 1 sawtooth.	Osc. 1, U2 Faulty (4558) Osc. 2, U6 Faulty (4558) Osc. 3, U9 Faulty (4558)
5. One or more waveforms not switching from STEP 3.	Check +15V enable inputs on: PULSE Pin13/Osc 1,U3 (4016) SAWTOOTH Pin 5/Osc 2,U7 (4016) TRIANGLE Pin 6/Osc 3,U10(4016)
6. OSC. 1 AND 2 dead but OSC. 3 is OK.	Faulty (3360) VCA, U4.
7. OSC. 3 is dead but OSC 1 & 2 are OK.	Faulty (3360) VCA, U13.
8. OSC. 1, 2 & 3 are dead but NOISE works.	Check for output on U12, Pin 1, (353/TL072). Replace if no output or latched at +15V or -15V. Signal may approach approximately 16V peak to peak, with associated mixer controls at maximum.

9. OSC. 1, 2, 3 & NOISE are ALL dead. Note: This normally indicates a VCF and/or VCA problem.	A) Observe input signal to VCF at "+" side of C26. This has a 40mV p-p small signal superimposed on a +1.37V DC level. B) Set front panel CUTOFF to maximum and EMPHASIS to minimum. C) The AC signal of STEP A should appear differentially on the output of the VCF ladder, U20 Pins 3 and 5. If signal is present, proceed to to STEP 12.
10. No VCF output from STEP 9C. This narrows the problem to either the VCF ladder or current source.	Bypass the VCF current source by shorting collector 2 of Q14 to ground (Base 2 of Q14). This forces the VCF wide open. If there is still no signal present at U20 pins 3 & 5, proceed to STEP 13.
11. Signal is present from STEP 10. Problem is in current source. U19, Q4, R173 through R176.	A) Remove short from Q14 (STEP 10) and place a jumper across R175 & observe signal at U20, Pins 3 & 5. B) If signal is still present, check DC voltage at U19 Pin 1 and replace if voltage is latched at +14V or -14V. C) If no signal is present from STEP 11A, check DC voltage at U19 Pin 6 for zero volts. D) If Pin 6 is zero, replace Q14. E) If Pin 6 is positive, jump Q14 Collector 1 to Collector 2 and recheck voltage at U19 Pin 6. F) If voltage is now zero, replace Q14: if voltage is not zero, replace U9.
12. VCF recovery amp.	Replace U20 (353 IC) if there is no signal on Pins 1 & 7. If signal is present, go to STEP 14.
13. VCF ladder problem.	A) Check for DC voltage balance of less than 0.1V difference between the emitters of the following transistor pairs; Q9-10, Q7-8, Q5-6 and Q14 Emitter 1 to Emitter 2. B) Replace any out of tolerance pairs. C) Go back to STEP 10 if any transistors were replaced. D) Replace C28 through 31 and go back to STEP 10. E) Check DC voltages on: Q11, Base 1 & 2; +1.4V Base of Q9 & 10; +2.7V Base of Q7 & 8; +4.1V Base of Q5 & 6; +5.5V Base 1 & 2 of Q4; +6.9V Replace bias network N2 if voltages deviate greatly from above and go to STEP 10. F) Replace all transistors Q4 through Q11 NOT replaced in STEP 13B and go to STEP 10.

14. VCA problem.	A) Check for about 40mv of signal on U22 pins 2 & 3. Go to STEP 12 if signals are not present. B) Short Q13 collector to ground (BASE) and check for signal on U22 Pin 6. Replace U22 if no signal is present. C) Replace Q13 if signal is present.
15. Emphasis problem.	A) Verify VCF is working - STEP 9 and 12. B) Short Q12 collector to ground and check VCF at U20 Pins 1 and 7 for sine wave oscillation. C) If no oscillation is present replace U20 and go to STEP 15B. D) Replace C28 through 31 and go to STEP 15B. E) Replace Q12.

CEM 3340

Voltage Controlled Oscillator

The CEM 3340 and CEM 3345 are completely self contained, precision voltage controlled oscillators, featuring both exponential and linear control scales and up to four buffered output waveforms: triangle, sawtooth, square, and pulse with voltage controllable pulse width. Full temperature compensation makes these VCOs extremely stable, and eliminates the need for a temperature compensation resistor. The highly accurate exponential and linear control inputs are virtual ground summing nodes, allowing multiple control voltages to be mixed within the device itself.

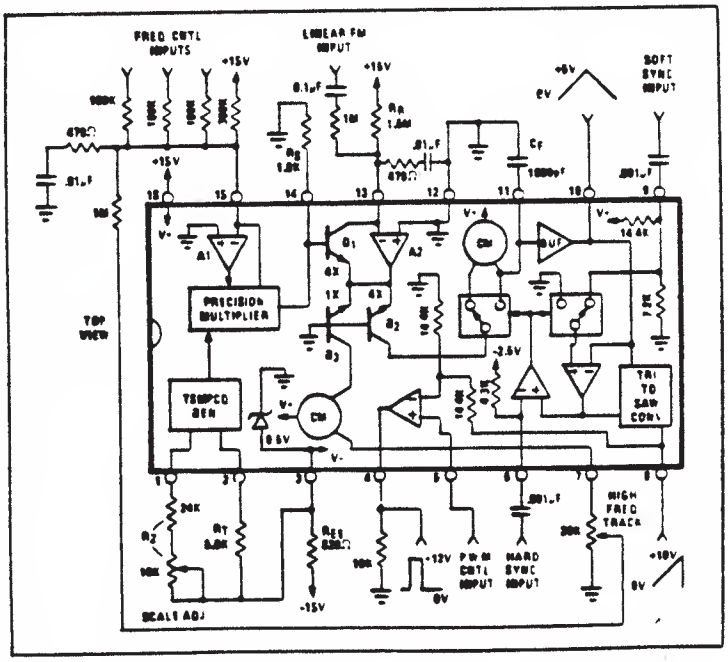
Also included is provision for hard and soft synchronization of the frequency, and an output for easy adjustment of high frequency tracking. Special care in the design ensures oscillation start-up under any power-on sequence and supply conditions.

Although a low voltage process has been used to reduce die size, cost, and leakage currents, an on-chip 6.5 volt zener diode allows the device to operate off ±15 volt supplies, as well as +15,-5 volt supplies.

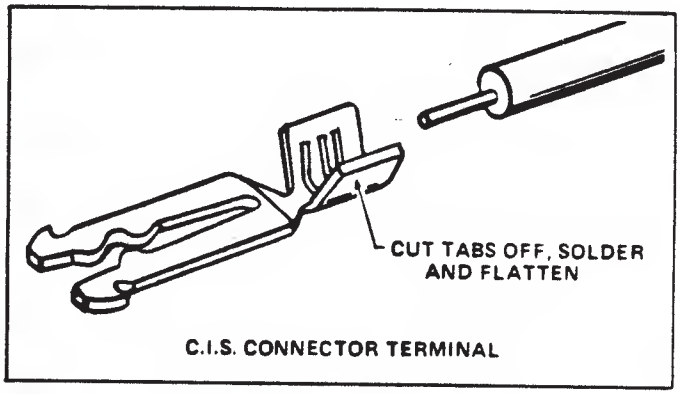
Absolute Maximum Ratings

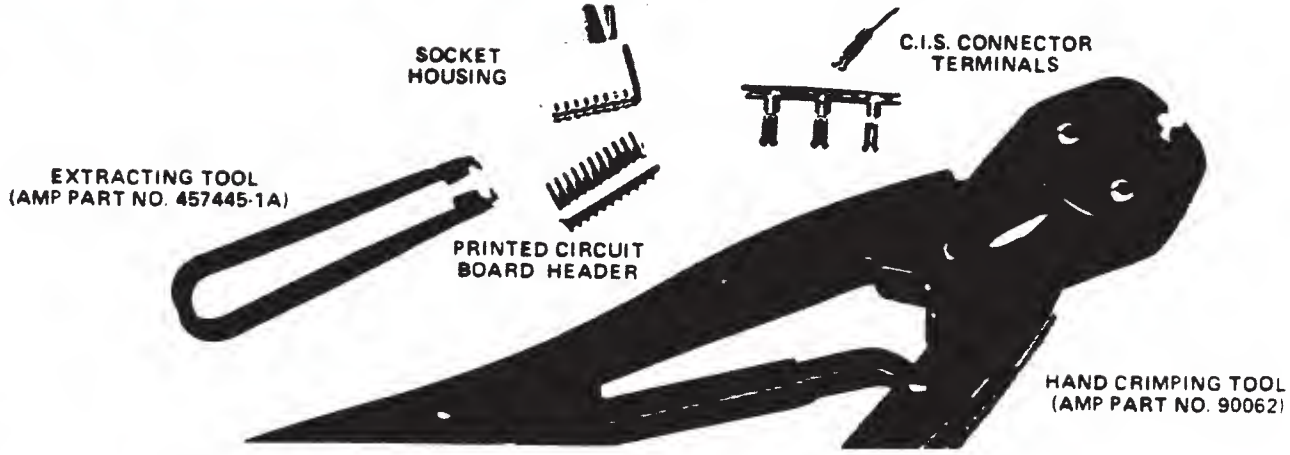
Voltage Between V_{CC} and V_{EE} Pins	+24V,-0.5V
Voltage Between V_{CC} and Ground Pins	+18V, -0.5V
Voltage Between V_{EE} and Ground Pins	-6.0V,+0.5V
Voltage Between Frequency Control Pin or Reference Current Pin and Ground Pin	±6.0V
Voltage Between Multiplier Output Pin and Ground Pin	+6.0V, -1V
Current through Any Pin	±40mA
Storage Temperature Range	-55°C to +150°C
Operating Temperature Range	-25°C to +75°C

CEM 3340 Circuit Block and Connection Diagram

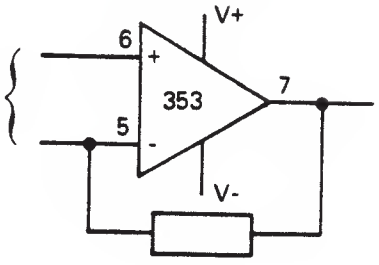


REPAIR AND TROUBLESHOOTING

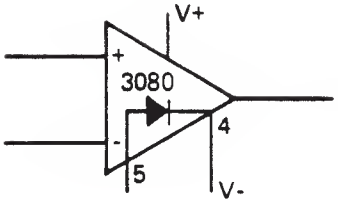




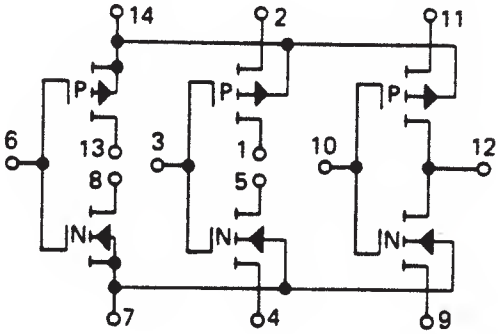
LINEAR IC



OTA



CMOS IC



CD4007A
Functional Diagram

Terminal No. 14–V_{DD}

Terminal No. 7–V_{SS}

MEMORYMOOG CALIBRATION PROCEDURE

INTRODUCTION

Most of the adjustments below are interdependent procedures which MUST be performed in the order presented, however, normal oscillator recalibration WILL NOT require all steps to be performed.

The Memorymoog PROMs have a considerable amount of diagnostic software built in, therefore, try the SOFTWARE TUNING procedure FIRST and the test equipment procedure only as necessary. The replacement of an IC that has an associated trim potentiometer will require recalibration, except that the replacement of a 3340 oscillator IC may ONLY require SOFTWARE oscillator TUNING - again try the SOFTWARE TUNING FIRST!

THE SOFTWARE OSCILLATOR TUNING OUTLINE

- o Find the out-of-tune oscillator(s).
- o Note the AUTOTUNE parameters and perform minor recalibration where necessary.
- o Perform major oscillator recalibration.

LOCATING THE OUT-OF-TUNE VOICE(S) AND OSCILLATOR(S)

- o Hit 2, ENTER for the straight brass program #2.
- o Hit KB MODE, 1 and ENTER to put the Memorymoog into the "POLY 1" mode (cyclic mode). The display will read "EDIT".
- o Hit C, 5 and ENTER to electrically center the oscillator frequency settings of oscillators 2 and 3 (unison). The display will read "FREQ CTR".
- o Hit C, 4 and ENTER and listen for an out-of-tune voice (rapid beating sound) by repeatedly playing the high C key. The display will initially read "DEFEAT ?" and then will indicate the voice being played, "1", "2", etc. WRITE DOWN THE OUT-OF-TUNE VOICE NUMBER!

For any out-of-tune voice, isolate and listen to each OSCILLATOR by turning on and off the individual waveform switches (SAWTOOTH) for oscillators 1, 2 & 3. This will locate the out-of-tune oscillator - WRITE DOWN THE OSCILLATOR NUMBER!

NOTING THE AUTOTUNE PARAMETERS

- o Hit C, 7, ENTER and ENTER again; the display will then query "VOICE ?"; hit the number of the voice above, which was out-of-tune, BUT DO NOT HIT ENTER!; Wait a second and the display will then query "OSC ?"; hit the number of the oscillator above which was out-of-tune but, again, DO NOT HIT ENTER; the display will then flash an expanded scale version of the AUTOTUNE voltages in a hexidecimal (HEX) format indicating from left to right a two digit RANGE, SCALE and HIGH TRIM code.
- o WRITE THESE VALUES DOWN with associated voice and oscillator numbers from above. Note that the second digit may "bobble" +/- one digit. An "ideally" tuned oscillator would display 7F 7F 7F. See the accompanying hexidecimal chart.

"DEAD OSC"

The AUTOTUNE voltages will flash so long as the oscillator is tuned within a +/- 50c range. However, if the oscillator's tuning is outside this capture range, the display will indicate "DEAD OSC". The oscillator usually is not dead but simply outside the AUTOTUNE range. See the MAJOR OSCILLATOR RECALIBRATION section of this procedure.

- o A MINOR RANGE ADJUSTMENT. If the SCALE and HI are within +/- 2 digits of the RANGE, but the RANGE is too far from the 7F nominal value, a simple range adjustment is all that is necessary. * indicates the trim being adjusted in the example.

EXAMPLE:	VOICE 1	OSC 1
52*	54	53
RANGE	SCALE	HI

A difference of 1 or 2 between these values means the oscillator is close enough in SCALE and HIGH TRIM but it's RANGE is too low.

EXAMPLE:	VOICE 1	OSC 1
7F*	81	80
RANGE	SCALE	HI

Readjustment of the RANGE to the 7F nominal value also brings the SCALE and HIGH TRIM to acceptable values. RANGE trim note: to INCREASE the RANGE readings, turn OSC 1 & 2 RANGE trims COUNTER-CLOCKWISE and OSC 3 RANGE trim CLOCKWISE.

- o TOUCH-UP TUNING. Complete readjustment will be necessary if there are differences between the three oscillator values exceeding +/- 2 DIGITS. Below is an example of this condition. * indicates the trim being adjusted in the example.

EXAMPLE:	VOICE 1	OSC 1
A3	9E*	94
RANGE	SCALE	HI

These oscillator values are very far apart; first adjust the SCALE to approximately EQUAL the RANGE. (Note that the SCALE trim affects the RANGE and HI). SCALE trim note: To INCREASE the "SCALE" readings, turn OSC 1 & 3 SCALE trims CLOCKWISE and OSC 2 SALE COUNTER-CLOCKWISE.

EXAMPLE:	VOICE 1	OSC 1
C1	C3	B0*
RANGE	SCALE	HI

Next adjust the TRIM to approximately EQUAL the RANGE and SCALE. HI trim note: To INCREASE the "HI" readings, turn, OSC 2 & 3 HI trims CLOCKWISE and OSC 1 HI trim COUNTER-CLOCKWISE.

EXAMPLE:	VOICE 1	OSC 1
C1*	C3	C1
RANGE	SCALE	HI

Lastly adjust the RANGE to the nominal value of 7F and the other adjustments will follow automatically.

EXAMPLE: VOICE 1 OSC 1

7F	81	7F
RANGE	SCALE	HI

This is the end of the software adjustment procedure for minor VOICE/OSCILLATOR recalibration. If it is necessary to proceed to identify other out-of-tune voices and/or oscillators, depress and "hold" the ENTER switch until the display reads "ENTER"; then hit ENTER again and the display will inquire as above for which VOICE and oscillator to display. An ENTER instruction will not be accepted if the flashing display is in an unlite state. To exit this mode of operation, hit ENTER when the display queries "VOICE?".

o MAJOR OSCILLATOR RECALIBRATION. Oscillators for which the display indicates "DEAD OSC" can be brought into range "by ear" using a tuned oscillator of the same VOICE as a reference source assuming the oscillator is simply out of the AUTOTUNE capture range.

This procedure will be required for a 3340 VCO replacement or for troubleshooting a suspected VCO that is swapped on a VOICE CARD to confirm tuning instability.

o Defeat all voices EXCEPT the one to be recalibrated. If, for example, VOICE 1 is out-of-tune, the following routine will defeat the other VOICES (2 through 6):

C, 4, ENTER "DEFEAT ?", 2 ENTER
C, 4, ENTER "DEFEAT ?", 3 ENTER
C, 4, ENTER "DEFEAT ?", 4 ENTER
C, 4, ENTER "DEFEAT ?", 5 ENTER
C, 4, ENTER "DEFEAT ?", 6 ENTER

This allows repeated notes to be played in the cyclic mode (POLY MODE 1) with only the out-of-tune oscillator showing in the ALPHANUMERIC DISPLAY.

o Hit 2, ENTER for the straight brass PROGRAM #2.

o Hit 4 foot OCTAVE for oscillators 1, 2 & 3.

o Hit C, 6, ENTER to clear out previous AUTOTUNE voltages.

o Hit C, 5, ENTER for a unison sound.

o Hit C, 4, ENTER and repeatedly play the high C key. Note that the ALPHANUMERIC display should ONLY show the VOICE to be recalibrated. If not, go back to the defeat routine above.

o Using the waveform selection switches (in this case, the SAWTOOTH switches), compare the out-of-tune oscillator with ONE of the good oscillators - the second good oscillator should be turned off.

o Hold down the low A (A1) and adjust the associated RANGE trim for unison.

o Hold down the MIDDLE (third) A (A3) and initially adjust the associated SCALE trim for "unison" but note the number of turns needed for unison (example: three turns clockwise). The SCALE trim significantly interacts with the RANGE trim, therefore, "overshoot" this SCALE trim by twice the number of turns (example: additional turns clockwise). Repeat the six RANGE and SCALE adjustments until both the low, and middle A notes will zero beat.

o Hold the High A (A5) and adjust the associated HI trim for zero beats.

Refer to the TOUCH UP tuning procedure above for further minor adjustments if the oscillator will not autotune. When this tuning procedure is completed, hit C4, ENTER, ENTER to ENABLE all six voices. The display will then indicate "ENABLE".

ABBREVIATED OSCILLATOR TUNING WITH EQUIPMENT

Using test equipment, a shortened oscillator tuning procedure may be accomplished as follows:

Perform POWER SUPPLY, DMUX and PRELIMINARY OSCILLATOR TUNING (Steps I, II and III); omit the next four steps - preliminary CONTOUR/GLIDE, preliminary COMMON ANALOG, FILTER tuning and VCA balance (Steps IV, V, VI and VII) -unless an associated part has been replaced; proceed with MAIN OSCILLATOR TUNING (Step VIII), MONOPHONIC SCALING adjustments (Step IX) and LHC - OCTAVE TRANSPOSE (Step X). Therefore, abbreviated oscillator tuning consists of only Steps I, II, III, VIII, IX and X.

The remaining adjustments, such as MODULATION OSCILLATOR (Step XI), PITCH WHEEL offset (Step XII), VOICE MODULATION offset (Step XIII) and FOOT PEDAL adjustments (Step XIV) can all be skipped unless associated parts have been replaced.

NOTE:

NOTE: When performing MAIN OSCILLATOR tuning Step VIII be aware that the SCALE trim SIGNIFICANTLY offsets the RANGE trim. To expedite tuning time, "over-shooting" the SCALE trim by factor of two in the opposite direction speeds tuning, eg. if the SCALE is 10c flat, turn the SCALE adjustment approximately 20c sharp.

WARMUP AND ACCURACY

Turn power on and allow unit to warm up at least ten minutes before attempting calibration. Use of a 4-1/2 digit DVM is NECESSARY for accurate calibration.

I. POWER SUPPLY ADJUSTMENTS

-15V SUPPLY ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)

1. Attach the negative DVM probe to the negative side of C74 and the positive probe to the negative side of C75, both on the DMUX board.

2. Adjust R8 on the POWER SUPPLY board for 15.000 volts.

+15 VOLT SUPPLY ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Attach the positive lead of the DVM to the plus side of C74 on the DMUX board.
2. Adjust R19 on the POWER SUPPLY board for 15.000 volts.

+5 VOLT SUPPLY ADJUSTMENT
1. Attach the plus lead of the DVM to the positive side of C73 on the DMUX board.
2. Adjust R33 on the POWER SUPPLY board for 5.000 volts.

II. DEMUX BOARD ADJUSTMENTS
+10 VOLT DAC REFERENCE ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Attach the DVM positive lead to the P518 side of R5 on the DMUX board.
2. Adjust R4 on the DMUX board for 10.000 volts.

DAC ZERO OUTPUT ADJUSTMENT
1. Attach the plus side of the DVM probe to the far side of R67 on the DMUX board.
2. Depress the 16' octave switch of OSCILLATOR 1.
3. Adjust R10, (DAC ZERO trim) on the DMUX board for 0.000 volts.

DAC FULL SCALE ADJUSTMENT (4-1/2 DIGIT DVM REQUIRED)
1. Depress the 2' OCTAVE switch on OSCILLATOR 1.
2. Adjust R8, the DAC FULLSCALE trim on the DMUX board to 10.000 volts.

III. PRELIMINARY OSCILLATOR TUNING FRONT PANEL SET-UP
1. Attach the DVM positive lead to the wiper of the TUNE pot and set the TUNE pot for 0.00V +/- 10mV.
2. Set up FRONT PANEL controls in Fig. 1.
3. Enter POLYPHONIC KEYBOARD MODE I by depressing "KB MODE", "1" and ENTER.
4. Electrically center Frequency 2 and Frequency 3 by depressing "C", "5" & ENTER.
5. Defeat AUTOTUNE by depressing "C", "6" & ENTER.
6. Remove keyboard from unit but do not disconnect keyboard wire harness.

IV. PRELIMINARY ADJUSTMENTS FOR CONTOUR/GLIDE
1. Attach DVM positive lead to the U2, Pin 7 side of R56 on the CONTOUR/GLIDE board.
2. Depress "MONO" button to turn it ON.
3. Depress the lowest note on the keyboard.
4. Adjust R53 for 0.000 volts.
5. Depress "MONO" button to turn it OFF.
6. Hold highest note on keyboard and depress and release "HOLD" button.
7. Release highest note.
8. Adjust R60 (TRANSPOSE SCALE I) on CONTOUR/GLIDE board for 0.000 volts.
9. Depress "HOLD" button to turn OFF.
10. Repeat Step 2 thru 9 if necessary to achieve 0.000 volts with no further adjustments.

V. PRELIMINARY ADJUSTMENTS FOR COMMON ANALOG
1. Attach DVM to Pin 7 on U15 on the COMMON ANALOG board.
2. Adjust R102 for 0.000 Volts.
3. Attach DVM to U16 Pin 7.
4. Adjust R111 for 0.000 Volts.
5. Attach DVM to U17 Pin 7.
6. Adjust R123 for 0.000 Volts.
7. Depress "MONO" switch to turn in ON.
8. Hit highest note on keyboard.
9. Adjust R136 for 4.708 volts with a 4-1/2 digit DVM.
10. Attach DVM to U16 Pin 7.
11. Adjust R120 for 4.708 volts with a 4-1/2 digit DVM.
12. Attach DVM to U15 Pin 7.
13. Adjust R107 for 4.708 volts with a 4-1/2 digit DVM.
14. Depress "MONO" button to turn it OFF.
15. Depress 2' range on all OSCILLATORS and hit highest note on keybaord.
16. Adjust R104 for 2.828 volts with a 4-1/2 digit DVM.
17. Attach DVM to U16 Pin 7.
18. Adjust R114 for 2.828 volts with a 4-1/2 digit DVM.
19. Attach DVM to U17 Pin 7.
20. Adjust R125 for 2.828 volts with a 4-1/2 digit DVM.
21. Set all OCTAVE switches to 4'.

VI. FILTER TUNING
FILTER SCALE, RANGE AND EMPHASIS ADJUSTMENT
1. Set FRONT PANEL controls as in Fig. 2.
2. Attach 400F A.C. voltmeter or equivalent, Strobe tuner and oscilloscope to R143 on VOICE CARD 1 (A VOICE).
3. Defeat VOICE CARDS 2 through 6 (B-F).
4A. Press "C", "4" and ENTER.
4B. The display will show "DEFEAT".
4C. Press "2" (for VOICE B) and ENTER.
4D. Repeat steps 4A through 4C for VOICES three through six. Substitute the appropriate voice number in Step 4C.
5. Attach DVM to wiper of VCF CUTOFF potentiometer.
6. Adjust control for 5.00 volts.
7. Depress and hold low C on keyboard.
8. Adjust EMPHASIS trim R153 for +10dBm (2.45Volts RMS, 6.9Volts peak-to-peak).
9. Adjust EMPHASIS BALANCE for a symmetrical sine wave.
10. Adjust FILTER RANGE trim R164 for E660Hz.
11. Depress and hold C3 on keyboard.
12. Adjust FILTER SCALE R167 for E2640Hz.
13. Depress and hold low C and repeat steps 10 through 12.
14. Repeat process for all other VOICE CARDS defeating the appropriate unused voices as in Step 4.

VII. VCA BALANCE ADJUSTMENT
1. Attach Hewlett Packard 400F A.C. voltmeter or equivalent to R143 on Voice Card 1.
2. Set up FRONT PANEL controls in Fig. 3.
3. Depress and release any note on the keyboard.
4. Adjust VCA trim R140 for minimum thump on A.C voltmeter.
5. Repeat for all other VOICE CARDS.

VIII. MAIN OSCILLATOR TUNING

NOTE:

NOTE: POWER SUPPLY and DMUX board adjustments must be verified with a 4-1/2 digit DVM before tuning is attempted. Set up FRONT PANEL controls as in Figure 3 and:

1. Attach Strobe tuner to the PULSE output of OSCILLATOR 1, VOICE CARD 1 at U3 Pin 1.
2. Defeat all VOICE CARDS except VOICE 1 (See Filter Tuning, Step 4, for procedure).
3. Depress low A.
4. Adjust R2 (OSC. 1 RANGE) for A220.
5. Depress A3, two octaves up.
6. Adjust R12 (OSC. 1 SCALE) for A880 (see "Overshooting" note above).
7. Repeat Steps 3 through 6 until a perfect 2 octave span is achieved.
8. Depress high A on the keyboard.
9. Adjust R10 (OSC. 1 HI END) for A3520.
10. Repeat Steps 3 through 9 until a perfect 5 octave span is achieved.
11. Repeat Steps 3 through 10 for OSCILLATOR 2 using junction of U7 Pin 1 for the Strobe tuner. Adjust R33 for A220, R44 for A880 and R42 for A3520.
12. Repeat Steps 3 through 10 for OSCILLATOR 3 using junction of U10 Pin 1 for the Strobe tuner. Adjust R75 for A220, R87 for A880 and R78 for A3520.
13. Repeat Steps 2 through 12 for VOICE CARDS 2 through 6 defeating appropriate unused voice cards in Step 2.
14. After all VOICE CARDS have been tuned, hit Low A and check the frequency of each OSCILLATOR on each VOICE CARD and adjust the appropriate range trim to A220, if necessary.
15. Enable all six voice cards by pressing "C", "4", ENTER, ENTER.

IX. MONOPHONIC SCALING ADJUSTMENT ON COMMON ANALOG BOARD

1. Attach Strobe tuner to OSCILLATOR 1 VOICE CARD 1 at U3 Pin 1.
2. Depress "MONO" button to turn it on.
3. Depress low A on keyboard.
4. Adjust OSCILLATOR 1 OFFSET R102 for A220.
5. Depress A3 on keyboard.
6. Adjust OSCILLATOR 1 SUM for A880.
7. Repeat Steps 3 through 6 until a perfect 2 octave span is achieved.
8. Repeat Steps 3 through 7 for OSCILLATOR 2 (U7 Pin 1) and OSCILLATOR 3 (U10 Pin 1).
9. Depress "MONO" button to turn it OFF.
10. Attach Strobe tuner to OSCILLATOR 1 VOICE CARD 1 at U3 Pin 1.
11. Depress A2 six times.
12. Depress 16' OCTAVE range on each OSCILLATOR.
13. Adjust OSCILLATOR 1 Offset for A110.
14. Depress 2' OCTAVE switch for OSCILLATOR 1.
15. Adjust OSCILLATOR 1 OCTAVE trim R104 for A880.
16. Repeat Steps 12 through 15 as necessary until a perfect 3 octave span is achieved.
17. Repeat Steps 12 through 16 for OSC2 (U7 Pin 1) and 3 (U10 Pin 1).
18. Press "AUTOTUNE" button and the display will show "6 TUNED" after about six seconds.

X. L.H.C. OCTAVE TRANSPOSE SCALE ADJUSTMENT

1. Attach Strobe tuner to OSC1 Voice 1 (U3 Pin 1).
2. Set OCTAVE switch for OSC1 to 4' range.
3. Depress Low A 220Hz.
4. Depress "-1" switch on LEFT HAND CONTROLLER.
5. Adjust the OCTAVE TRANSPOSE trim R32 for A110.
6. Depress "0" switch on LEFT HAND CONTROLLER.

XI. MODULATION OSCILLATOR RANGE AND SCALE

1. Attach a Time Interval Counter or Scope to the junction of R181, R182 and R183 on the COMMON ANALOG board.
2. Turn the MODULATION RATE Control fully counter-clockwise. Adjust R198 for a time period of 10.0 seconds.
3. Turn the MODULATION RATE Control fully clockwise. Adjust R200 for a time period of 10 milliseconds.

XII. PITCH WHEEL OFFSET ADJUSTMENT

1. Attach DVM probe to wiper of PITCH WHEEL.
2. Loosen PITCH WHEEL setscrew and mechanically adjust PITCH WHEEL pot shaft to achieve 0 volts +/-.1 volt on wiper if necessary.
3. Tighten setscrew on PITCH WHEEL.
4. Recheck voltage and readjust if necessary.
5. Attach Strobe tuner to OSC1 VOICE 1 (U3 Pin 1).
6. Depress low A.
7. Turn PITCH BEND amount control full, clockwise.
8. Adjust PITCH Offset trim R67 on COMMON ANALOG board for no pitch shift.
9. Turn PITCH BEND AMOUNT fully counter-clockwise.

XIII. VOICE MODULATION OFFSET ADJUSTMENTS

1. Turn off all three wave shapes of OSCILLATOR 3 on FRONT PANEL.
2. Set the front panel VOICE MODULATION section controls as follows: OSCILLATOR 3 and FILTER ENVELOPE fully CCW, FREQUENCY 1 button ON and all other VOICE MODULATION buttons off.
3. Set front panel VOLTAGE CONTROLLED FILTER controls all fully CCW.
4. Attach STROBE tuner to OSCILLATOR 1 VOICE CARD 1 (U3 Pin 1).
5. Hit Low A and note the pitch.
6. Turn OSC. 3 control fully CW.

7. Adjust R106 (OSCILLATOR 3 OFFSET) on VOICE CARD for no pitch shift.
8. Turn OSC. 3 control fully CCW.
9. Turn FILTER ENVELOPE control fully CW.
10. Adjust CONTOURED MOD OFFSET trim on CONTOUR/GLIDE BOARD for no pitch shift (R128 VOICE 1, R161 VOICE 2, R190 VOICE 3, R219 VOICE 4, R248 VOICE 5, R277 VOICE 6).
11. Turn FILTER ENVELOPE control fully CCW.
12. Repeat Steps 5 through 11 above for VOICE CARDS 2 through 6 using Pin 1 of U3 on the associated VOICE CARD for the STROBE tuner and the associated offset trim of Step 10.

XIV. FOOT PEDAL INPUT ADJUSTMENT
1. Plug shorting jack into FOOT PEDAL 1.
2. Attach a STROBE tuner to OSCILLATOR 1 VOICE 1 (U3 Pin 1) and turn FOOT PEDAL AMOUNT controls 1 and 2 fully CCW.
3. Depress lowest A on keyboard.
4. Depress FOOT PEDAL PITCH button to turn it ON.
5. Adjust F.P.1 ZERO R8 on COMMON ANALOG board for no pitch shift.
6. Turn FOOT PEDAL AMOUNT 1 to maximum.
7. Adjust F.P.1 OFFSET R3 for no pitch shift.
8. Depress FOOT PEDAL PITCH button to turn it off.
9. Attach STROBE tuner to OSC2 VOICE 1 (U7 Pin 1).
10. Depress FOOT PEDAL OSC2 button to turn it on.
11. Adjust F.P.2 ZERO R17 for no pitch shift.
12. Turn FOOT PEDAL AMOUNT 2 clockwise.
13. Adjust F.P.2 offset R12 for no pitch shift.
14. Depress FOOT PEDAL OSC2 button to turn it off.

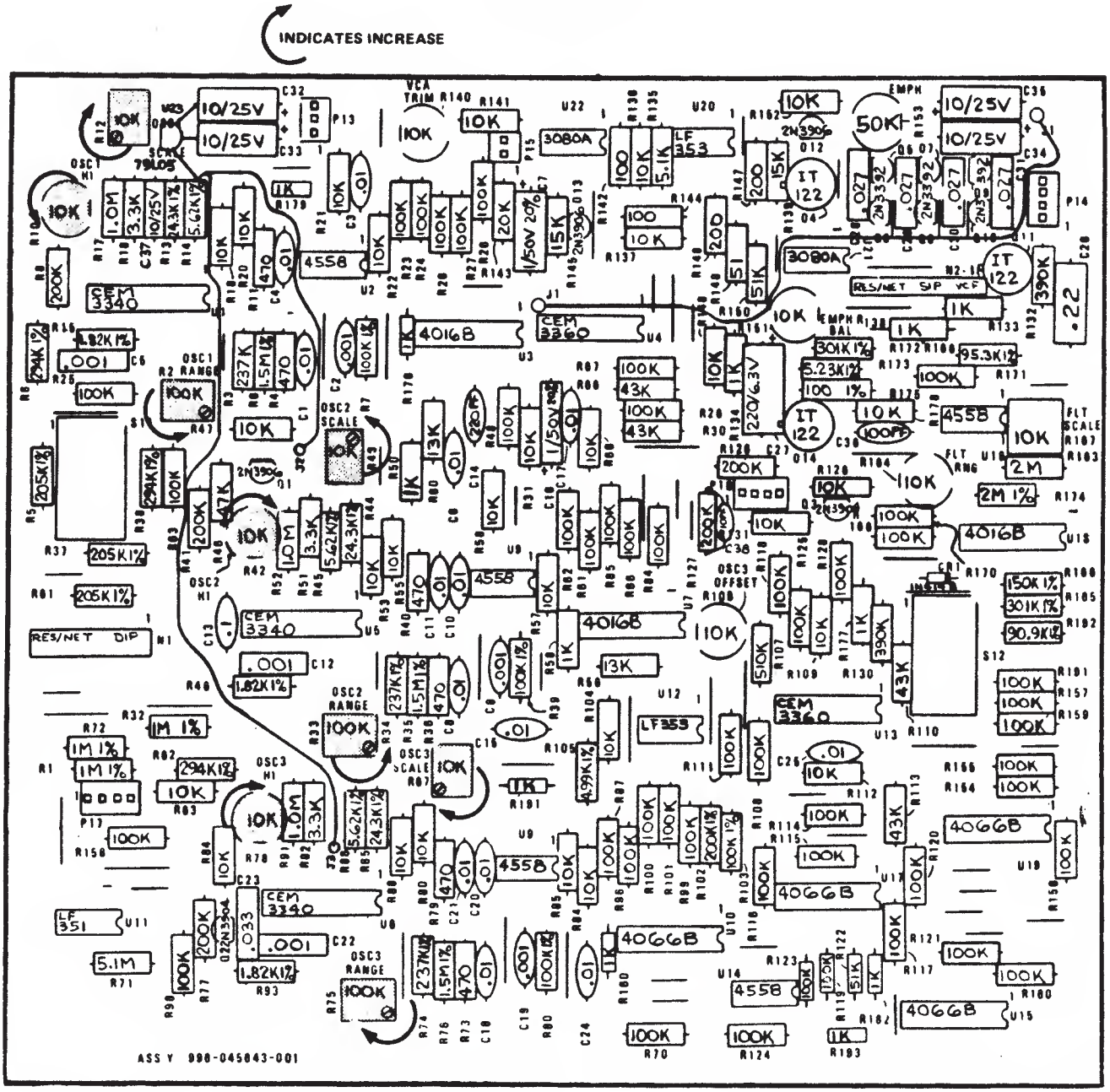
HEXIDECIMAL AUTOTUNE CHART
(DECIMAL EQUIVALENTS)

	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F
	10	11	12	13	14	15	16	17	18	19	1A	1B	1C	1D	1E	1F
	20	21	22	23	24	25	26	27	28	29	2A	2B	2C	2D	2E	2F
	30	31	32	33	34	35	36	37	38	39	3A	3B	3C	3D	3E	3F
	40	41	42	43	44	45	46	47	48	49	4A	4B	4C	4D	4E	4F
	50	51	52	53	54	55	56	57	58	59	5A	5B	5C	5D	5E	5F
	60	61	62	63	64	65	66	67	68	69	6A	6B	6C	6D	6E	6F
#	70	71	72	73	74	75	76	77	78	79	7A	7B	7C	7D	7E	7F*
#	80	81	82	83	84	85	86	87	88	89	8A	8B	8C	8D	8E	8F
	90	91	92	93	94	95	96	97	98	99	9A	9B	9C	9D	9E	9F
	A0	A1	A2	A3	A4	A5	A6	A7	A8	A9	AA	AB	AC	AD	AE	AF
	B0	B1	B2	B3	B4	B5	B6	B7	B8	B9	BA	BB	BC	BD	BE	BF
	C0	C1	C2	C3	C4	C5	C6	C7	C8	C9	CA	CB	CC	CD	CE	CF
	D0	D1	D2	D3	D4	D5	D6	D7	D8	D9	DA	DB	DC	DD	DE	DF
	E0	E1	E2	E3	E4	E5	E6	E7	E8	E9	EA	EB	EC	ED	EE	EF
	F0	F1	F2	F3	F4	F5	F6	F7	F8	F9	FA	FB	FC	FD	FE	FF

* NOMINAL ADJUSTMENT VALUE - 7F

NOMINAL CAPTURE RANGE OF THE AUTOTUNE CIRCUIT IS FROM 70 HEX TO 8F HEX FOR THE RANGE.

VOICE CARD



MODIFICATIONS

Update the accompanying schematics before proceeding with repair or calibration.

DMUX BOARD #5
Update pin 16 of 4051 IC's.

U10 through U17 to +15 volts - current schematics erroneously indicate +5 volts.

CALIBRATION DIAGRAM

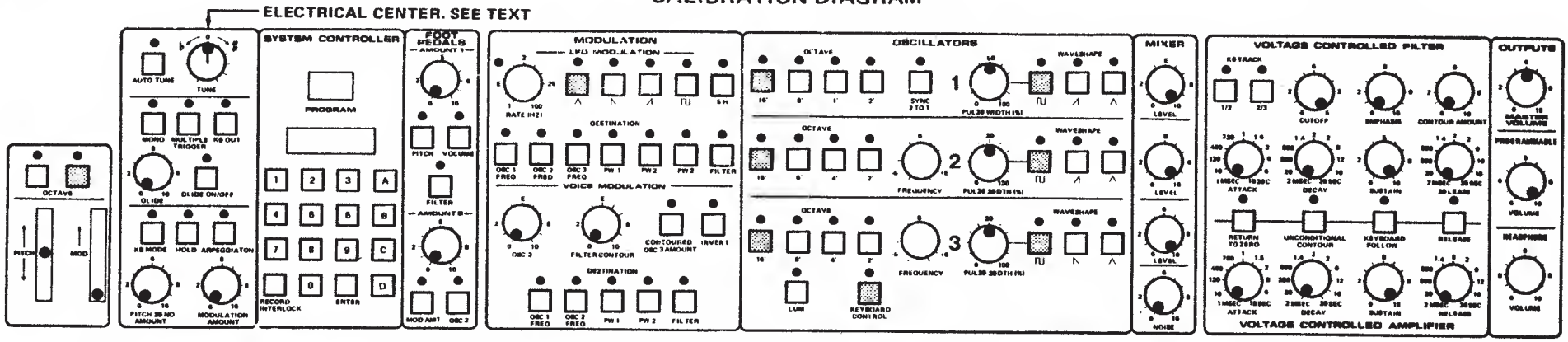


FIGURE 1 PRELIMINARY OSCILLATOR TUNING SET-UP

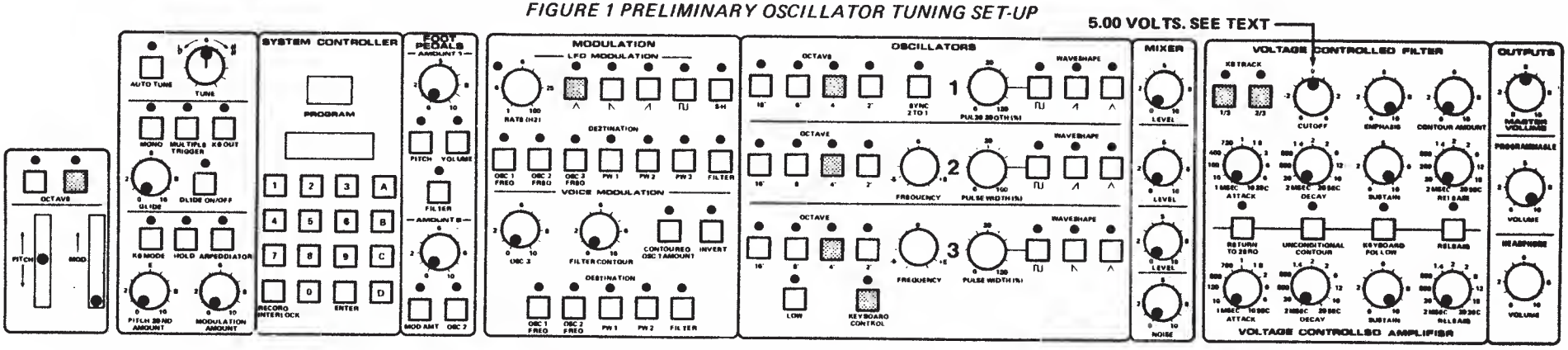


FIGURE 2 FILTER TUNING

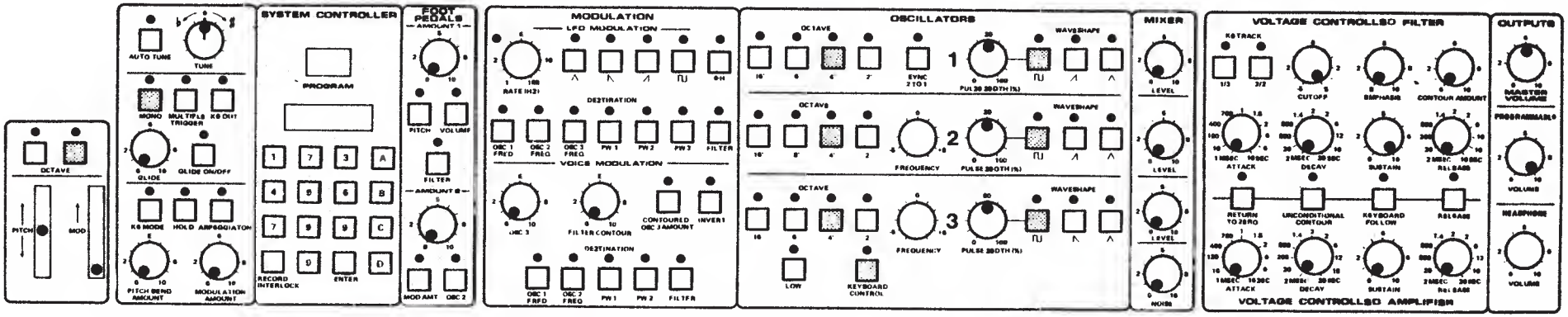


FIGURE 3 VCA BALANCE AND MAIN OSCILLATOR TUNING

MEMORYMOOG

PARTS LIST

SPECIAL NOTE

The following 4558 integrated circuits have been substituted with 1458 integrated circuits on some Memorymoog production runs. Field replacement should be effected with 4558 IC's as noted on schematics.

VOICE CARD, BOARD #1
U2, U6, U9 & U19

COMMON ANALOG BOARD #2
U2, U9, U10, U15-U21, U23 & U26.

CONTOUR/GLIDE BOARD #3
U1, U3, U5, U7, U11, U12, U13, U21, U22, U29, U37, U38, U45, U53, U54 & U61.

GENERAL PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
345	997-045821-001	MEMORYMOOG, 100-127 VOLTS	200100 PRODUCT #
345X	997-045821-002	MEMORYMOOG, 200-254 VOLTS	200101 PRODUCT #
(1)	935-044665-101	CASSETTE, FACTORY PROGRAMS	SPECIAL ORDER
(2)	915-041298-002	KNOB, DUAL CONCENTRIC	FREQUENCY 2 & 3
(30)	997-041867-002	KNOB ASSEMBLY, POINTER	ALL OTHERS
(1)	932-045880-100	PACKING MATERIAL, COMPLETE	INCLUDES MANUAL
(1)	932-045890-002	FOAM, BOTTOM FILLER, PRECUT	39.8 X 20 X 1.5"
(2)	932-045890-001	FOAM, SIDE FILLER, RECTANGULAR	8.9 X 20 X 1.5"
(1)	932-045889-001	FOAM, TOP FILLER, PRECUT	39.9 X 20 X 7.0"
(1)	932-045888-001	CARTON, SHIPPING	44.5 X 21 X 9.5"
(1)	932-040643-001	BAG, POLY PACKING, TUBULAR	77.0 X 23 X .01"
(1)	997-045924-001	OWNER/SERVICE MANUAL ASSEMBLY	3 RING BINDER
(1)	997-044666-001	PROM UPDATE KIT (SOFTWARE)	LATEST VERSION
(1)	997-044667-001	MEMORYMOOG ROAD KIT	SELECTED PARTS

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
	908-045886-001	INSULATOR, FISH PAPER	6.4" X 16.1"
	962-045827-001	END CAP, LEFT HAND ALUMINUM	
	962-045827-002	END CAP, RIGHT HAND ALUMINUM	
	962-045828-001	LOGO, MEMORYMOOG ALUMINUM	FRONT PANEL
	962-045832-001	COVER PLATE ALUMINUM	INTERFACE PANEL
	967-045822-001	HOUSING, CABINET COMPLETE	
	967-045823-001	FRONT PANEL, ALUMINUM	LHC & KEYBOARD
	967-045825-001	BASE, ALUMINUM	
	967-045830-005	STIFFENER, BASE ALUMINUM	L-BRACKET
(3)	967-045831-001	BRACKET 3/4 X 13/16 X 5/8	VINYL CLAD, END CAP
(9)	967-045831-002	BRACKET 1 X 1 X 5/8	VINYL CLAD, END CAP
(2)	967-045831-003	BRACKET 1 X 5/16 X 5/8	VINYL CLAD, END CAP
	967-045883-001	DOUBLER PLATE, BASE	TRANSFORMER SUPPORT
	972-045826-001	SIDE PANEL, LEFT SIDE WOOD	5/8" WALNUT
	972-045826-002	SIDE PANEL, RIGHT SIDE WOOD	5/8" WALNUT
	972-045829-004	TRIM, BLOCK HOUSING WOOD	5/8" WALNUT
	972-045829-001	TRIM, CENTER BRACE WOOD	1" MAPLE UNFINSHED
	972-045829-002	TRIM, FRONT KEYBOARD WOOD	3/8" MAPLE
	972-045829-003	TRIM, RIGHT SIDE WOOD	3/8" MAPLE
	972-045829-005	TRIM, LEFT SIDE WOOD	3/8" MAPLE
	979-045424-001	KEYBOARD, C TO C	61 NOTE
	964-044686-001	KEY, WHITE C	
	964-044686-002	KEY, WHITE D	
	964-044686-003	KEY, WHITE E	
	964-044686-004	KEY, WHITE F	
	964-044686-005	KEY, WHITE G	
	964-044686-006	KEY, WHITE A	
	964-044686-007	KEY, WHITE B	
	964-044686-008	KEY, WHITE HIGH C	
	964-044686-009	KEY, BLACK	
	975-044687-001	SPRING	
	913-045588-001	OVERLAY, CONTROLS LEFT SIDE	
	913-045588-002	OVERLAY, CONTROLS CENTER	
	913-045588-003	OVERLAY, CONTROLS RIGHT SIDE	
	913-045588-004	OVERLAY, LEFT HAND CONT.	
	915-040524-002	VINYL TIP 1/8 X 3/8 WHITE	VOICE CARD INSULATOR
(2)	915-041298-002	KNOB, DUAL CONCENTRIC	
(30)	997-041867-002	KNOB, POINTER ASSEMBLY	
(41)	802-045322-000	NUT, HEX KEPS ZINC	6-32
(6)	904-041406-010	WASHER, INSULATED FIBRE	6 X 5/16" OD
(4)	904-041391-010	WASHER, FLAT ZINC	10 X 3/4" OD
(26)	973-040508-063	STANDOFF, HEX ZINC	6-32 X .625"
(4)	973-040789-003	STANDOFF, HINGED CADMIUM	6-32 X 3/4"
(4)	973-040789-004	STANDOFF, HINGED CADMIUM	6-32 X 1"
(20)	973-040517-001	STANDOFF, MALE-FEMALE, HEX	6-32 X 1/4"
(4)	973-040508-066	STANDOFF, HEX ZINC	6-32 X 1 1/8"
(4)	973-040508-064	STANDOFF, HEX ZINC	6-32 X 3/4"
(30)	812-045039-004	SCREW, SEMS PAN HEAD BLACK	6-32 X 1/4"
(9)	806-045039-006	SCREW, MACHINE BLACK	6-32 X 3/8"
(6)	973-045326-001	SUPPORT, PC BOARD SCR MOUNT	1/4"
(6)	811-040311-004	SCREW, SELF TAPPING NICKEL	6A X 1/4"
(6)	904-041395-009	WASHER, LOCK SPRING ZINC	#8
(6)	903-044310-001	SCREW, MACHINE	5M X 12 MM
(12)	816-050039-006	SCREW, SELF TAPPING BLACK	8B X 3/8"
(4)	916-042584-001	FOOT, BLACK RUBBER	7/8 DIA X 3/8"
(3)	902-040500-001	NUT, TINNERMAN "U" TYPE	#6A
(3)	811-040039-008	SCREW, SELF TAPPING BLACK	6A X 1/2" BLK
(10)	903-045216-001	SCREW, .165/.175	#8 X 5/8"
(11)	811-050039-008	SCREW, SELF TAPPING BLACK	8A X 1/2"
(10)	811-050039-016	SCREW, SELF TAPPING BLACK	8A X 1"
(8)	811-050039-020	SCREW, SELF TAPPING BLACK	8A X 1-1/4"
(20)	904-041395-008	WASHER, LOCK SPRING CADMIUM	#8
(1)	911-040189-002	LUG, CRIMP	#8
(1)	801-055446-000	NUT, HEX ZINC	8-32
(17)	916-045163-001	BUMPER, RUBBER	
(12)	904-040495-021	WASHER, LOCK NICKEL	3/8
(16)	904-042026-001	WASHER, FLAT NICKEL	3/8 CONICAL
(18)	902-040504-007	NUT, HEX	3/8-32
	904-040495-015	WASHER, LOCK INTERNAL TOOTH	#4
(2)	904-040507-020	SPACER, BLACK OXIDE	#4
	811-040331-004	SCREW, SELF-TAPPING NICKEL	6A X 1/4"
(10)	904-040495-016	WASHER, LOCK INTERNAL TOOTH	#6
	806-023039-006	SCREW, MACHINE BLACK	4-40 X .375"
(2)	801-045332-000	NUT, HEX KEPS BLACK	6-32
(8)	806-055039-005	SCREW, MACHINE CADMIUM	8-32 X 5/16"
(4)	802-055449-000	NUT, HEX KEPS	8-32
(4)	806-055032-010	SCREW, MACHINE CADMIUM	8-32 X 5/8"
(2)	806-065232-006	SCREW, MACHINE FLAT HD	10-32 X 3/8"
	913-040328-001	OVERLAY, MOOG LOGO	
(6)	904-041546-003	WASHER, INSULATED FIBRE	3/8 X 5/8"
(2)	904-041309-007	WASHER, FLAT	#8
(4)	973-040609-303	SPACER, ALUMINUM	#6 X 1/4"
(4)	806-045039-010	SCREW, MACHINE BLACK	6-32 X 5/8"
(3)	910-041316-001	PIN, CONTACT UNIV. MATE-N-LK	
(1)	906-040392-001	CONN, .045 SQ.SOCKET HSG. 15 PIN .156" CNTRS.	
(14)	910-040393-002	CONTACT, SOCKET, .045 SERIES	
(1)	910-045921-016	CONN, 16 PIN HSG. MOLEX	
(16)	910-045922-001	TERMINAL, CRIMP MOLEX	
(26)	910-040308-001	CONN, CIS CRIMP SOCKET	
(3)	910-040310-001	CONN, CIS KEYING PLUG	
S13ACEF	910-045895-203	CONN, MTA HOUSING RED 22AWG 3 PIN	
S13B	910-045895-003	CONN, MTA HOUSING RED 22AWG 3 PIN	
S13D	910-045895-003	CONN, MTA HOUSING RED 22AWG 3 PIN	
S14ACDEF	910-045895-204	CONN, MTA HOUSING RED 22AWG 4 PIN	
S14B	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN	
S15A-F	910-045895-002	CONN, MTA HOUSING RED 22AWG 2 PIN	
S16A-F	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN	
S17A-F	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN	
S24	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	
S25	910-045895-007	CONN, MTA HOUSING RED 22AWG 7 PIN	
S26	920-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	
S27	920-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN	
S28	910-045895-005	CONN, MTA HOUSING RED 22AWG 5 PIN	
S29	910-045895-007	CONN, MTA HOUSING RED 22AWG 7 PIN	
S31	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN	
S34	910-045895-005	CONN, MTA HOUSING RED 22AWG 5 PIN	
S35	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	
S36A-F	910-045895-003	CONN, MTA HOUSING RED 22AWG 3 PIN	
S30	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	
S42	910-045895-005	CONN, MTA HOUSING RED 22AWG 5 PIN	
S44	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	
S47	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN	

S16A-F	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S17A-F	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S24	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S25	910-045895-007	CONN, MTA HOUSING RED 22AWG 7 PIN
S26	920-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S27	920-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S28	910-045895-005	CONN, MTA HOUSING RED 22AWG 5 PIN
S29	910-045895-007	CONN, MTA HOUSING RED 22AWG 7 PIN
S31	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN
S34	910-045895-005	CONN, MTA HOUSING RED 22AWG 5 PIN
S35	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S36A-F	910-045895-003	CONN, MTA HOUSING RED 22AWG 3 PIN
S30	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S42	910-045B95-005	CONN, MTA HOUSING RED 22AWG 5 PIN
S44	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S47	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S48A-B	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN
S63	910-045895-008	CONN, CIS SOCKET HOUSING 8 PIN .1 CT
S64	910-045895-008	CONN, CIS SOCKET HOUSING 8 PIN .1 CT
S77	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN
S78	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN
S91	906-040298-008	CONN, CIS SOCKET HOUSING 8 PIN .1 CT
S92	906-040298-005	CONN, CIS SOCKET HOUSING 5 PIN .1 CT
S511	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
S512	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S513	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S514	910-045895-002	CONN, MTA HOUSING 2 PIN GROUND
S514	910-045895-002	CONN, MTA HOUSING 2 PIN +15 VOLT
S514	910-045895-002	CONN, MTA HOUSING 2 PIN -15 VOLT
S515A-F	910-045895-003	CONN, MTA HOUSING RED 22AWG 3 PIN
S516	910-045895-010	CONN, MTA HOUSING RED 22AWG 10 PIN
S517	910-045895-004	CONN, MTA HOUSING RED 22AWG 4 PIN
S518	910-045895-007	CONN, MTA HOUSING RED 22AWG 7 PIN
S519	910-045895-008	CONN, MTA HOUSING RED 22AWG 8 PIN
S520	910-045895-006	CONN, MTA HOUSING RED 22AWG 6 PIN
P11-P53	994-045350-101	RIBBON CABLE ASSY, 16 PIN DIP 54.5" 7 PLUGS
P12-P54	994-045350-102	RIBBON CABLE ASSY, 16 PIN DIP 59.0" 7 PLUGS
P21-P55	994-045350-008	RIBBON CABLE ASSY, 16 PIN DIP 13.0" 2 PLUGS
P22-P56	994-045350-006	RIBBON CABLE ASSY, 16 PIN DIP 11.5" 2 PLUGS
P23-P57	994-045350-013	RIBBON CABLE ASSY, 16 PIN DIP 7.5" 2 PLUGS
P32-P58	994-045350-009	RIBBON CABLE ASSY, 16 PIN DIP 16.5" 2 PLUGS
P33-P59	994-045350-007	RIBBON CABLE ASSY, 16 PIN DIP 12.5" 2 PLUGS
P43-P52	994-045350-010	RIBBON CABLE ASSY, 16 PIN DIP 18.5" 2 PLUGS
P44-P73	994-045350-012	RIBBON CABLE ASSY, 16 PIN DIP 29.5" 2 PLUGS
P45-P51	994-045350-005	RIBBON CABLE ASSY, 16 PIN DIP 11.0" 2 PLUGS
P46-P71	994-045350-011	RIBBON CABLE ASSY, 16 PIN DIP 22.0" 2 PLUGS
P61-P75	994-045350-005	RIBBON CABLE ASSY, 16 PIN DIP 11.0" 2 PLUGS
P62-P72	994-045350-011	RIBBON CABLE ASSY, 16 PIN DIP 22.0" 2 PLUGS

HARNESSING ASSEMBLYS

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
S47-J14-J15-J16	994-045894-972	HARNESS, CASSETTE INTERFACE	
S76-BD8	994-045894-975	HARNESS, DISPLAY BOARD POWER	
S74-BD8	994-045894-946	HARNESS, DISPLAY BOARD DATA	
S24-BD10 R1 & R2	994-045894-963	HARNESS, LEFT HAND CONTROLLER	
S78-S63	994-045894-977	HARNESS, POWER, LSC TO RSC	
S26-S518	994-045894-965	HARNESS, POWER COMMON ANALOG	
S40-S520	994-045894-970	HARNESS, POWER DIGITAL BOARD	
S42-S517 J11	994-045894-971	HARNESS, DEMUX/DIGITAL BOARD CLOCK	
S27-S92 S1-S41-J12	994-045894-966	HARNESS, TO BACK PANEL JACKS	
S29-S15 A THRU F	994-045894-960	HARNESS, SHIELDED, VOICE AUDIO	
S516-S25 S77-S64	994-045894-964	HARNESS, POWER AND DEMUX TO LSC/RSC	
S36A-F S16A-F S35A-F	994-045894-961	HARNESS, KBRD CV AND ADSR TO VOICE CARDS	
S511A-F S17A-F S515A-F	994-045894-962	HARNESS, AUTOTUNE AND OSC3 ENABLES	
S519-S31	994-045894-968	HARNESS, POWER TO CONTOUR/GLIDE BOARD	
S512 S14A-F	994-045894-978	HARNESS, CHAIN, 7.5V, ETC. TO VOICE CARDS	
S514 S13A-F	994-045894-979	HARNESS, CHAIN, 15V AND GROUND TO VOICE CARDS	
S48A&B S121	994-045894-973	HARNESS, KEYBOARD TO DIGITAL BOARD	
S28-BD5 PADS 1-4	994-045894-967	HARNESS, DEMUX AND MISC. TO COMMON ANALOG	
S131-P510 PADS 1-15	994-045894-974	HARNESS, POWER TO DEMUX BOARD	
S34-S91 S513	994-045894-969	HARNESS, POWER AND ADSR TO JACKS	

MEMORYMOOG PACKING MATERIAL

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	932-045890-002	FOAM, BOTTOM FILLER	
(2)	932-045890-001	FOAM, SIDE FILLER	
(1)	932-045889-001	FOAM, INSERT	
(1)	932-045888-001	CARTON, SHIPPING	
(1)	932-040643-001	BAG, POLY PACKING	
(1)	997-045924-001	PACKET, OWNER'S/SERVICE ASSEMBLY 3 RING BINDER	

MEMORYMOOG POWER CONNECTIONS

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	910-042913-001	RECEPTACLE, POWER	CEE-22
(1)	913-044099-001	LABEL, SAFETY GROUND	EXPORT
(1)	913-045130-006	LABEL, VOLTAGE	115V
(1)	913-045130-005	LABEL, VOLTAGE	220V EXPORT
(1)	954-045882-001	TRANSFORMER	
	957-041794-001	CORD, POWER 3 CONDUCTOR	18 AWG, 5' DOMESTIC
	957-043400-001	CORDSET, EUROPEAN	EXPORT
	960-042800-001	SWITCH, ROCKER, DPST	250V/8A ON/OFF
	997-045885-001	FUSE PLATE ASSEMBLY	120 VOLT DOMESTIC
(1)	806-023039-006	SCREW, PAN HEAD BLACK	4-40 X 3/8"
(1)	906-041331-006	FUSEHOLDER, SINGLE .250 TAB	
(1)	939-041620-006	FUSE, SLO-BLO 3AG 250V	1.25AMP
(1)	962-045931-001	PLATE, ALUMINUM	FUSE COVER
	997-045885-002	FUSE PLATE ASSEMBLY	220 VOLT EXPORT
(5)	806-023039-006	SCREW, PAN HEAD BLACK	4-40 X 3/8"
(1)	906-042911-003	FUSEHOLDER, CLIP TYPE	5 X 20MM
(1)	939-044094-013	FUSE,TIME LAG	5 X 20MM 800MA
(1)	939-044094-011	FUSE,TIME LAG	5 X 20MM 315MA
(3)	939-044094-002	FUSE,TIME LAG	5 X 20MM 3.15A
(1)	962-045931-001	PLATE, ALUMINUM	FUSE COVER
(1)	969-045948-001	SHIELD, FISH PAPER	FORMED

MEMORYMOOG FAN ASSEMBLY PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(4)	802-065542-000	NUT, HEX KEPS CADMIUM	10-32
(4)	806-065032-010	SCREW, MACHINE CADMIUM	10-32 X 5/8"
(4)	916-045961-001	MOUNT, VIBRATION RUBBER	
	935-045940-001	FAN MOTOR, 115VAC	50/60 HERTZ
	935-045940-002	FAN BLADE	
(2)	967-045941-901	BRACKET, FAN PEM INSERTED	

MEMORYMOOG POWER SUPPLY BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(3)	906-045188-014	SOCKET, IC DIP 14 PIN	
(4)	906-042676-001	SOCKET, TIP TRANSISTOR	
(4)	903-042674-001	SCREW, SELF TAPPING	4-40 X 1"
(4)	908-042674-001	INSULATOR, MICA	
(4)	904-042729-001	WASHER, SHOULDER INSULATED	
	968-045928-001	HEATSINK, COUPLER PLATE	
P131	910-042533-015	HEADER, .156" CTRS.	15 PIN NON-LOCKING
P132	910-042531-003	HEADER, .156" CTRS.	3 PIN LOCKING
P133	910-042531-003	HEADER, .156" CTRS.	3 PIN LOCKING
P134	910-042531-003	HEADER, .156" CTRS.	3 PIN LOCKING
U1	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
U2	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
U3	991-041484-001	IC, VOLTAGE REGULATOR DIP	723C
Q1	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q2	991-041056-001	TRANSISTOR, NPN 60V/2A	MPS U05
Q3	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q4	991-041056-001	TRANSISTOR, NPN 60V/2A	MPS U05
Q5	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q6	991-042663-001	TRANSISTOR, NPN 40V/6A	TIP41
Q7	991-041056-001	TRANSISTOR, NPN 60V/2A	MPS U05
CR1-CR4	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR5	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR6	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR7	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR8-CR11	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR12	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR13	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR14	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
CR15	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR16	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR17	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR18	919-041157-001	DIODE, RECTIFIER 3A/200PIV	MR502
CR19	919-041255-002	DIODE, ZENER 22V/1WATT	1N4748A
CR20	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
C1	945-040209-043	CAPACITOR, ALUMINUM ELECT.	3300 UFD/35V
C2	947-042020-471	CAPACITOR, CERAMIC DISC	470 PFD
C3	945-040209-042	CAPACITOR, ALUMINUM ELECT.	1000 UFD/16V
C4	945-040209-043	CAPACITOR, ALUMINUM ELECT.	3300 UFD/35V
C5	947-042020-471	CAPACITOR, CERAMIC DISC	470 PFD
C6	945-040209-007	CAPACITOR, ALUMINUM ELECT.	470 UFD/35V
C7	945-040209-037	CAPACITOR, ALUMINUM ELECT.	4700 UFD/16V
C8	947-042020-471	CAPACITOR, CERAMIC DISC	470 PFD
C9	945-040209-007	CAPACITOR, ALUMINUM ELECT.	470 UFD/35V
R8	925-042526-001	POT, TRIM CERMET	1K +15V ADJ
R19	925-042526-001	POT, TRIM CERMET	1K -15V ADJ
R33	925-042526-001	POT, TRIM CERMET	1K +5V ADJ

MEMORYMOOG CONTOUR/GLIDE BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(28)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(21)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(14)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
	910-040299-002	HEADER, CIS .1" CNTRS.	2 PIN
P36	910-040299-003	HEADER, CIS .1" CNTRS.	3 PIN
P34	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
P35	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
	910-040299-007	HEADER, CIS .1" CNTRS.	7 PIN
P31	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
U1	991-041146-001	IC, DUAL OP AMP	4558
U2	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U3	991-041146-001	IC, DUAL OP AMP	4558
U4	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U5	991-041146-001	IC, DUAL OP AMP	4558
U6	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U7	991-041146-001	IC, DUAL OP AMP	4558
U8	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U9	991-041087-001	IC, CMOS QUAD BILAT. SWITCH	4016B
U10	991-041087-001	IC, CMOS QUAD BILAT. SWITCH	4016B
U11	991-041146-001	IC, DUAL OP AMP	4558
U12	991-041146-001	IC, DUAL OP AMP	4558
U13	991-041146-001	IC, DUAL OP AMP	4558
U14	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U15	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U16	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U17	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U18	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U19	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U20	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U21	991-041146-001	IC, DUAL OP AMP	4558
U22	991-041146-001	IC, DUAL OP AMP	4558
U23	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U24	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U25	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U26	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U27	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U28	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U29	991-041146-001	IC, DUAL OP AMP	4558
U30	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U31	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U32	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U33	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U34	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U35	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U36	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U37	991-041146-001	IC, DUAL OP AMP	4558
U38	991-041146-001	IC, DUAL OP AMP	4558
U39	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U40	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U41	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U42	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U43	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U44	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U45	991-041146-001	IC, DUAL OP AMP	4558
U46	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U47	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U48	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32

U49	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U50	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U51	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U52	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U53	991-041146-001	IC, DUAL OP AMP	4558
U54	991-041146-001	IC, DUAL OP AMP	4558
U55	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U56	991-043554-001	IC, LSTTL QUAD 2 INPUT AND	74LS08
U57	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U58	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U59	991-045868-001	IC, VC ENVELOPE GENERATOR	CEM3310
U60	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U61	991-041146-001	IC, DUAL OP AMP	4558
Q1-Q7	991-041064-001	TRANSISTOR, FET N-CHANNEL	2N4303
Q8-Q19	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
CR1-CR6	919-041075-001	DIODE, SIGNAL	1N4148
C1	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C2	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C3	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C4	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C5	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C6	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C7	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C10	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C11	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C12	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C13	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C14	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C15	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C16	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C19	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C20	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C21	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C22	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C23	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C24	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C25	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C26	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C27	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C28	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C29	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C30	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C31	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C32	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C33	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C34	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C35	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C36	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C37	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C38	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C39	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C40	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C41	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C42	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C43	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C44	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C45	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C46	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C47	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C48	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C49	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C50	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C51	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C52	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C53	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C54	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C55	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C56	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C57	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C58	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C59	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C60	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C61	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C62	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C63	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C64	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C65	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C66	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C67	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C68	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C69	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C70	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C71	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C72	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C73	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C74	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C75	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C76	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 NFD
C77	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C78	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C78	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C80	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C81	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C82	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C83	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C84	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C85	946-041978-332	CAPACITOR, POLYESTER BOX	3.3 NFD
C86	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C87	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C88	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UF
C89	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C91	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UF
R1-2	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R12-13	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R26	925-040275-004	POT, TRIM CARBON	10K GLIDE RNG C&D
R18-19	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R29-30	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R35-36	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R43	925-040275-004	POT, TRIM CARBON	10K GLIDE RNG E&F
R46-47	949-044333-002	RESISTORS, MATCHED PAIR	100K,1% (TO .01%)
R53	925-040275-004	POT, TRIM CARBON	10K TRNSPE OFFSET
R60	925-042526-003	POT, TRIM CERMET	10K TRNSPSE SCL
R77	925-040275-004	POT, TRIM CARBON	10K MONO GLD RNG
R128	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR A
R131	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET A
R161	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR B
R164	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET B
R190	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR C
R193	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET C
R219	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR D
R222	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET D
R248	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR E
R251	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET E
R277	925-040275-003	POT, TRIM CARBON	50K VCE MOD CNTR F
R280	925-040275-003	POT, TRIM CARBON	50K VCF CNTR OFFSET F

MEMORYMOOG DIGITAL BOARD

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
	802-045322-000	NUT, HEX KEPS	6-32
	806-045309-006	SCREW, MACHINE, BLACK	6-32 3/8"
	816-040039-006	SCREW, SELF TAPPING, BLACK	6B X 3/8"
	902-042525-001	NUT, TINNERMAN "U" TYPE	#6
P40	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
P41	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P42	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
P47	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P48A	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
P48B	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
P49	910-040299-003	HEADER, CIS .1" CNTRS.	3 PIN
(1)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(10)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(15)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(3)	906-045188-020	SOCKET, IC DIP .3" CNTRS.	20 PIN
(7)	906-045188-024	SOCKET, IC DIP .6" CNTRS.	24 PIN
(1)	906-045188-028	SOCKET, IC DIP .6" CNTRS.	28 PIN
(2)	906-045188-040	SOCKET, IC DIP .6" CNTRS.	40 PIN
BT1	926-045312-001	BATTERY, LITHIUM	3 VOLT
Y1	921-045313-001	CRYSTAL, QUARTZ	4 MEGAHERTZ
K1	921-045141-001	RELAY, REED SPST	500 OHM COIL
Q1-Q3	991-041052-001	TRANSISTOR, PNP SMALL SIG	2N3906
CR1-CR3	919-041075-001	DIODE, SIGNAL	1N4148
CR4-CR9	919-042019-001	DIODE, RECTIFIER 1A/400PIV	1N4004
C1	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C2	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C3	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C4	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C5	946-040231-001	CAPACITOR, TANTALUM	1.5 UFD/20V
C6	947-045008-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
C7	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	947-045008-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
C10	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C11	946-041978-104	CAPACITOR, POLYESTER BOX	.01 UFD
C12	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C13	946-040231-002	CAPACITOR, TANTALUM	10 UFD/20V
C14	945-044465-008	CAPACITOR, ALUMINUM ELECT.	47 UFD/16V
C15	947-045011-103	CAPACITOR, MONOLITHIC	.1 UFD
C16	945-040209-014	CAPACITOR, ALUMINUM ELECT.	2.2 UFD/25V
C17	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C18	947-045008-471	CAPACITOR, CERAMIC TUBULAR	470 PFD
C19	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C20	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C21-C32	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
U1	991-045306-01	IC, MICROPROCCESOR	Z-80 CPU
U2	991-045307-001	IC, UVEPROM 4K BY 8	2532
U3	991-045307-001	IC, UVEPROM 4K BY 8	2532
U4	991-045307-001	IC, UVEPROM 4K BY 8	2532
U5	991-045530-001	IC, CMOS RAM 2K BY 8	6116LP
U6	991-045530-001	IC, CMOS RAM 2K BY 8	6116LP
U7	991-045530-001	IC, CMOS RAM 2K BY 8	6116LP
U9	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U10	991-045867-001	IC, COUNTER/TIMER	Z-80 CTC
U11	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U12	991-043552-001	IC, LSTTL QUAD 2 INPUT NOR	74LS02
U13	991-043577-001	IC, LSTTL QUAD 2 INPUT NAND	74LS00
U14	991-043553-001	IC, LSTTL HEX INVERTER	74LS04
U15	991-043520-001	IC, CMOS HEX SCHMITT TRIG.	40106B
U16	991-045299-001	IC, LSTTL DUAL D FLIP/FLOP	74LS74
U17	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U18	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U19	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U20	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U21	991-043553-001	IC, LSTTL HEX INVERTER	74LS04
U22	991-045549-001	IC, LSTTL QUAD 2 INPUT NAND	74LS26
U23	991-042388-001	IC, DUAL COMPARATOR	LF393
U24	991-041112-001	IC, VOLTAGE REGULATOR 5V	78M05C
U25	991-043532-001	IC, LSTTL QUAD 2 INPUT OR	74LS32
U26	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U27	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U28	991-045865-001	IC, LSTTL OCTAL D FLIP/FLOP	74LS377
U29	991-045864-001	IC, LSTTL OCTAL BUS TRNSCVR	74LS245
U30	991-045866-001	IC, CMOS HEX TRI-STATE BUF	4503B
U31	991-043550-001	IC, LSTTL DUAL 4-BIT CNTR	74LS393
U32	991-045865-001	IC, LSTTL OCTAL D FLIP/FLOP	74LS377
U33	991-045299-001	IC, LSTTL DUAL D FLIP/FLOP	74LS74
U34	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138
U35	991-043555-001	IC, LSTTL DECODER/DMUX	74LS138

MEMORYMOOG COMMON ANALOG BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
CR1	919-044466-001	DIODE, LOW LEAKAGE	FDH333
CR2	919-044466-001	DIODE, LOW LEAKAGE	FDH333
CR3	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR4	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR5	919-041349-004	DIDOE, ZENER 8.2V/500 MW	1N5237A
CR6	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR7	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR8	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR9	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR10	919-041349-004	DIDOE, ZENER 8.2V/500 MW	1N5237A
CR11	919-041349-004	DIDOE, ZENER 8.2V/500 MW	1N5237A
CR12	919-041075-001	DIODE, SMALL SIGNAL	1N4148
CR13	919-041075-001	DIODE, SMALL SIGNAL	1N4148
Q1	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q2	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q3	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q4-Q6	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q7	991-041055-001	TRANSISTOR, FET N-CHANNEL	E112
Q8	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q9	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q10	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
U1	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U2	991-041146-001	IC, DUAL OP AMP	4558
U3	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U4	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U5	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U6	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U7	991-042908-001	IC, DUAL JFET OP AMP	LF353 (TL072)
U8	991-045137-001	IC, AUDIO OP AMP	LM386
U9	991-041146-001	IC, DUAL OP AMP	4558
U10	991-041146-001	IC, DUAL OP AMP	4558
U11	991-045870-001	IC, DUAL VOLTAGE CONT AMP	CEM3360
U12	991-041101-001	IC, OP AMP	741
U13	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U14	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U15	991-041146-001	IC, DUAL OP AMP	4558
U16	991-041146-001	IC, DUAL OP AMP	4558
U17	991-041146-001	IC, DUAL OP AMP	4558
U18	991-041146-001	IC, DUAL OP AMP	4558
U19	991-041146-001	IC, DUAL OP AMP	4558
U20	991-041146-001	IC, DUAL OP AMP	4558
U21	991-041146-001	IC, DUAL OP AMP	4558
U22	991-045869-001	IC, VOLTAGE CONTROLLED OSC	CEM3340
U23	991-041146-001	IC, DUAL OP AMP	4558
U24	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U25	991-042016-001	IC, DIGITAL NOISE SOURCE	5837
U26	991-041146-001	IC, DUAL OP AMP	4558
U27	991-042908-001	IC, DUAL JFET OP AMP	LF353 (TL072)
U28	991-041087-001	IC, CMOS QUAD SWITCH	4016B
C1	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C2	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C3	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C4	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C5	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C6	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C7	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C8	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C9	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C10	945-044465-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C11	946-041978-473	CAPACITOR, POLYESTER BOX	.047 UFD
C12	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
C13	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C14	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C15	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C16	947-045001-221	CAPACITOR, CERAMIC TUBULAR	220 PFD
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C19	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C20	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C21	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C22	945-040209-014	CAPACITOR, ALUMINUM ELECT.	2.2 UFD/25V
C23	946-041978-124	CAPACITOR, POLYESTER BOX	.12 UFD
C24	946-041978-333	CAPACITOR, POLYESTER BOX	.033 UFD
C25	946-041978-223	CAPACITOR, POLYESTER BOX	.022 UFD
C26	946-041978-104	CAPACITOR, POLYESTER BOX	.1 UFD
C27	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C28	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C29	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C30	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C31	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C32	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C33	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C34	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C35	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C36	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C37	947-045008-472	CAPACITOR, CERAMIC TUBULAR	4.7 NFD
(17)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(10)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(4)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
P24	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P25	910-040299-007	HEADER, CIS .1" CNTRS.	7 PIN
P26	910-040299-006	HEADER, CIS .1" CNTRS.	6 PIN
P27	910-040299-010	HEADER, CIS .1" CNTRS.	10 PIN
P28	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
P29	910-040299-007	HEADER, CIS .1" CNTRS.	7 PIN
R3	925-040275-004	POT, TRIM CARBON	10K FP1 OFFSET
R8	925-040275-004	POT, TRIM CARBON	10K FP1 ZERO
R12	925-040275-004	POT, TRIM CARBON	10K FP2 OFFSET
R17	925-040275-004	POT, TRIM CARBON	10K FP2 ZERO
R30	925-042389-002	POT, TRIM CERMET	10K OCT TRANS
R37	925-040275-003	POT, TRIM CARBON	50K VOICE B LEVEL
R39	925-040275-003	POT, TRIM CARBON	50K VOICE C LEVEL
R41	925-040275-003	POT, TRIM CARBON	50K VOICE D LEVEL
R43	925-040275-003	POT, TRIM CARBON	50K VOICE E LEVEL
R45	925-040275-003	POT, TRIM CARBON	50K VOICE F LEVEL
R67	925-042389-002	POT, TRIM CERMET	10K PITCH OFFSET
R84	925-040275-004	POT, TRIM CARBON	10K MOD OFFSET
R102	925-042389-002	POT, TRIM CERMET	10K OSC 1 OFFSET
R104	925-042389-012	POT, TRIM CERMET	50K OSC 1 OCTAVE
R107	925-042389-002	POT, TRIM CERMET	10K OSC 1 SUM
R111	925-042389-002	POT, TRIM CERMET	10K OSC 2 OFFSET
R114	925-042389-012	POT, TRIM CERMET	50K OSC 2 OCTAVE
R120	925-042389-002	POT, TRIM CERMET	10K OSC 2 SUM
R123	925-042389-002	POT, TRIM CERMET	10K OSC 3 OFFSET
R125	925-042389-012	POT, TRIM CERMET	50K OSC 3 OCTAVE
R136	925-042389-002	POT, TRIM CERMET	10K OSC 3 SUM
R198	925-040275-004	POT, TRIM CARBON	10K MOD RATE SCL
T1	955-045879-001	TRANSFORMER, AUDIO DRIVER	600 OHM BAL. LINE

MEMORYMOOG DEMUX BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(36)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(5)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(32)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(2)	906-045188-020	SOCKET, IC DIP .3" CNTRS.	20 PIN
P511	910-040299-006	HEADER, .1" CNTRS.	6 PIN
P512	910-040299-004	HEADER, .1" CNTRS.	8 PIN
P513	910-040299-004	HEADER, .1" CNTRS.	4 PIN
P514	910-040299-006	HEADER, .1" CNTRS.	6 PIN
P515A	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P515B	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P515C	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P515D	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P515E	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P515F	910-040299-003	HEADER, .1" CNTRS.	3 PIN
P516	910-040299-010	HEADER, .1" CNTRS.	10 PIN
P517	910-040299-004	HEADER, .1" CNTRS.	4 PIN
P518	910-040299-007	HEADER, .1" CNTRS.	7 PIN
P519	910-040299-008	HEADER, .1" CNTRS.	8 PIN
P520	910-040299-006	HEADER, .1" CNTRS.	6 PIN
P521	910-040299-006	HEADER, .1" CNTRS.	6 PIN
P522	910-040299-006	HEADER, .1" CNTRS.	6 PIN
U1	991-043559-001	IC, LSTTL OCTAL D F/F	74LS378
U2	991-045865-001	IC, LSTTL HEX D F/F	74LS377
U3	991-045356-001	IC, INTERFACE 12 BIT DAC	6012
U4	991-041101-001	IC, OP AMP	741
U5	991-042793-001	IC, OP AMP	LF351 (TL071)
U6	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393
U7-U9	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U10-U17	991-041090-001	IC, CMOS 8 CHAN MULTIPLEXER	4051
U18-U49	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U50	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U51	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U52	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U53	991-045862-001	IC, TTL HEX INVERTER	7416
U54-U61	991-043518-001	IC, CMOS HEX D FLIP/FLOP	40174B
U62	991-041146-001	IC, DUAL OP AMP	4558
Q1-Q12	991-041052-002	TRANSISTOR, PNP SMALL SIG	2N3906
Q13	991-041051-002	TRANSISTOR, NPN SMALL SIG	2N3904
Q14	991-045872-001	TRANSISTOR, PNP MED POWER	TN2905
CR1	919-041078-002	DIODE, ZENER 6.2V/250MW	1N823
CR2	919-041075-001	DIODE, SIGNAL	1N4148
CR3	919-041075-001	DIODE, SIGNAL	1N4148
CR4	919-041349-004	DIODE, ZENER 8.2V/500MW	IN5237A
C1	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C2	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C3	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C4	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C5	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C6	945-044465-003	CAPACITOR, ALUMINUM ELECT	10 UFD/25V
C7-C70	946-041978-103	CAPACITOR, POLYESTER BOX	.01 UFD
C71	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C72	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C73-C75	945-044465-003	CAPACITOR, ALUMINUM ELECT	10 UFD/25V
C76-C103	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
R4	925-042389-003	POT, TRIM CERMET	1K +10V ADJ
R8	925-042389-002	POT, TRIM CERMET	10K FULL SCALE ADJ
R10	925-042389-006	POT, TRIM CERMET	100K ZERO ADJ

MEMORYMOOG VOICE CARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(10)	906-045188-008	SOCKET, IC DIP .3" CTRS.	8 PIN
(9)	906-045188-014	SOCKET, IC DIP .3" CTRS.	14 PIN
(5)	906-045188-016	SOCKET, IC DIP .3" CTRS.	16 PIN
P13	910-040299-003	HEADER, CIS .1" CTRS.	3 PIN
P14	910-040299-004	HEADER, CIS .1" CTRS.	4 PIN
P15	910-040299-002	HEADER, CIS .1" CTRS.	2 PIN
P16	910-040299-004	HEADER, CIS .1" CTRS.	4 PIN
P17	910-040299-004	HEADER, CIS .1" CTRS.	4 PIN
Q1	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q2	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q3	991-041051-002	TRANSISTOR, NPN SMALL SIG.	2N3904
Q4	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
Q5-Q10	991-042017-002	TRANSISTOR, NPN SMALL SIG.	2N3392
Q11	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
Q12	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q13	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q14	991-045871-001	TRANSISTOR, NPN DUAL PAIR	IT122
U1	991-045869-001	IC, VC OSCILLATOR	CEM3340
U2	991-041146-001	IC, DUAL OP AMP	4558
U3	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U4	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U5	991-045869-001	IC, VC OSCILLATOR	CEM3340
U6	991-041146-001	IC, DUAL DP AMP	4558
U7	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U8	991-045869-001	IC, VC OSCILLATOR	CEM3340
U9	991-041146-001	IC, DUAL OP AMP	4558
U10	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U11	991-042793-001	IC, BIFET OP AMP	LF351 (TL071)
U12	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U13	991-045870-001	IC, DUAL VC AMPLIFIER	CEM3360
U14	991-041146-001	IC, DUAL DP AMP	4558
U15-U18	991-041087-001	IC, CMOS QUAD SWITCH	4016B
U19	991-041146-001	IC, DUAL OP AMP	4558
U20	991-042908-001	IC, DUAL BIFET OP AMP	LF353 (TL072)
U21	991-041089-004	IC, OPER. TRANSCOND. AMP	3080A
U22	991-041089-004	IC, OPER. TRANSCOND. AMP	3080A
U23	991-044316-101	IC, VOLTAGE REGULATOR -5V	79L05

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
CR1	919-041075-001	DIODE, SIGNAL	1N4148
C1	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C2	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C3	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C4	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C5	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C6	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C7	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C8	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C9	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C10	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C11	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C12	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C13	947-045183-104	CAPACITOR, MONOLITHIC	.1 UFD
C14	947-045008-221	CAPACITOR, CERAMIC TUBULAR	220 PFD
C15	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C16	945-044465-002	CAPACITOR, ALUMINUM ELECT.	1 UFD/50V
C17	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C18	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C19	947-045008-102	CAPACITOR, CERAMIC TUBULAR	.001 UFD
C20	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C21	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C22	946-041978-102	CAPACITOR, POLYESTER BOX	.001 UFD
C23	946-041978-333	CAPACITOR, POLYESTER BOX	.033 UFD
C24	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C25	947-045011-103	CAPACITOR, CERAMIC TUBULAR	.01 UFD
C26	946-040190-224	CAPACITOR, POLYESTER	.22 UF
C27	945-044465-006	CAPACITOR, ALUMINUM ELECT.	220 UFD/6.3V
C28-C31	946-041978-273	CAPACITOR, POLYESTER BOX	.027 UFD
C32-C35	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C36	947-045008-101	CAPACITOR, CERAMIC TUBULAR	100 PFD
C37	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C38	947-045011-100	CAPACITOR, CERAMIC TUBULAR	10 PFD
R2	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 1 RANGE
R10	925-040275-004	POT, TRIM CARBON	10K OSC 1 HI
R12	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 1 SCALE
R33	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 2 RANGE
R42	925-040275-004	POT, TRIM CARBON	10K OSC 2 HI
R43	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 2 SCALE
R75	925-040378-007	POT, TRIM CERMET 20 TURN	100K OSC 3 RANGE
R78	925-040275-004	POT, TRIM CARBON	10K OSC 3 HI
R87	925-040378-001	POT, TRIM CERMET 20 TURN	10K OSC 3 SCALE
R106	925-040275-004	POT, TRIM CARBON	10K DSC 3 DFFSET
R140	925-040275-004	POT, TRIM CARBON	10K VCA OFFSET
R151	925-040275-004	POT, TRIM CARBON	10K EMPHASIS BAL
R153	925-040275-004	POT, TRIM CARBON	10K EMPHASIS AMNT
R164	925-040275-004	POT, TRIM CARBON	10K VCF RANGE
R167	925-042389-002	POT, TRIM CERMET	10K VCF SCALE
N1	949-045875-001	NETWORK, RESISTOR DIP .1%	100K
N2	949-040207-001	NETWORK, RESISTOR SIP	

MEMORYMOOG — LEFT SIDE CONTROL BOARD — PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(8)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(4)	906-045188-020	SOCKET, IC DIP .6" CNTRS.	20 PIN
(1)	910-042392-003	HEADER, CIS RT ANGLE	3 PIN
(1)	910-042392-007	HEADER, CIS RT ANGLE	7 PIN
(1)	910-042392-008	HEADER, CIS RT ANGLE	8 PIN
	967-045830-001	"L" BRACKET, BOTTOM LSC	
	967-045830-003	"L" BRACKET, TOP LSC	
(48)	975-045466-001	SPRING, COMPRESSION	SWITCH
(32)	964-044082-001	BUTTON, DARK GRAY	
(48)	960-045861-001	SWITCH, CONTACT SPRING	
(48)	960-045861-002	SWITCH, CONTACT BUTTON	
SW33	964-044082-112	BUTTON, SWITCH LIGHT GREY	"A"
SW34	964-044082-113	BUTTON, SWITCH LIGHT GREY	"8"
SW35	964-044082-114	BUTTON, SWITCH LIGHT GREY	"C"
SW36	964-044082-115	BUTTON, SWITCH LIGHT GREY	"D"
SW37	964-044082-105	BUTTON, SWITCH LIGHT GREY	"3"
SW38	964-044082-108	BUTTON, SWITCH LIGHT GREY	"6"
SW39	964-044082-111	BUTTON, SWITCH LIGHT GREY	"9"
SW40	964-044082-002	BUTTON, SWITCH LIGHT GREY	" "
SW41	964-044082-104	BUTTON, SWITCH LIGHT GREY	"2"
SW42	964-044082-107	BUTTON, SWITCH LIGHT GREY	"5"
SW43	964-044082-110	BUTTON, SWITCH LIGHT GREY	"8"
SW44	964-044082-101	BUTTON, SWITCH LIGHT GREY	"0"
SW45	964-044082-102	BUTTON, SWITCH LIGHT GREY	"1"
SW46	964-044082-106	BUTTON, SWITCH LIGHT GREY	"4"
SW47	964-044082-109	BUTTON, SWITCH LIGHT GREY	"7"
SW48	964-044082-002	BUTTON, SWITCH LIGHT GREY	" "
U1	991-045950-001	IC, LSTTL OCTAL D F/F	74LS273
U2	991-045876-001	IC, TRANSISTOR ARRAY	2074
U3	991-045876-001	IC, TRANSISTOR ARRAY	2074
U4	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377
U5	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377
U6	991-045865-001	IC, LSTTL OCTAL D F/F	74LS377
U7	991-045866-001	IC, CMOS HEX 3 STATE BUFF	4503B
U8	991-043559-001	IC, LSTTL HEX D F/F	74LS378
U9	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U10	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U11	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U12	991-041112-004	IC, VOLT REG +6 VOLT	78M06
U13	991-045305-001	IC, TTL HEX BUFFER	7417
U14	991-042388-001	IC, DUAL COMPARATOR	LM393
Q1-Q18	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
(33)	939-045874-001	LED, HIGH BRIGHTNESS	RED
C1	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C2	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C3-C16	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C17	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C18	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C19	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C20-C22	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C23	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C24	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C25	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C26	945-040209-019	CAPACITOR, ALUMINUM ELECT.	220 UFD/16V
C27	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C28	946-041978-472	CAPACITOR, POLYESTER BOX	4.7 NFD
R61	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K GLIDE
R62	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K BEND AMT
R63	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K MOD AMT
R64	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K FT. PED. 1 AMT
R65	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K FT. PED. 2 AMT
R66	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K MOD RATE
R67	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K VOICE MOD OSC 3
R68	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K VOICE MOD VCF
R69	925-045880-001	POT, ROTARY PC MTG. LINEAR	10K TUNE

MEMORYMOOG — DISPLAY BOARD — PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(2)	904-041406-009	WASHER, FLAT FIBRE	#4 X 9/32"
(2)	816-040039-006	SCREW, SELF TAPPING	#6B X 3/8"
(2)	902-042525-001	NUT, TINNERMAN "U" TYPE	#6
(2)	910-040299-001	HEADER, CIS 1 PIN	
U1	991-043559-001	IC, LSTTL HEX D FLIP/FLOP	74LS378
U2	991-041097-001	IC, TTL BCD 7 SEG DECODER	7447
U3	939-042633-002	DISPLAY, 7 SEGMENT, 2 DIGIT	MAN6610
U4	939-045873-001	DISPLAY, 8 CHARACTER, ALPHA	LT1604
Q1	991-041057-001	TRANSISTOR, PNP 60V/2A	MPSU55
Q2	991-041057-001	TRANSISTOR, PNP 60V/2A	MPSU55
C1	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD

MEMORYMOOG RIGHT SIDE CONTROL BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(1)	906-045188-008	SOCKET, IC DIP .3" CNTRS.	8 PIN
(1)	906-045188-014	SOCKET, IC DIP .3" CNTRS.	14 PIN
(7)	906-045188-016	SOCKET, IC DIP .3" CNTRS.	16 PIN
(2)	910-042392-008	HEADER, CIS RT ANGLE	8 PIN
	967-045830-002	L BRACKET, BOTTOM RSC	
	967-045830-004	L BRACKET, TOP RSC	
(30)	975-045466-001	SPRING, COMPRESSION	SWITCH
(30)	964-044082-001	BUTTON, DARK GRAY	
(30)	960-045861-001	SWITCH, CONTACT SPRING	
(30)	960-045831-002	SWITCH, CONTACT BUTTON	
U1	991-045866-001	IC, CMOS HEX TRISTATE BUFF	4053B
U2	991-043559-001	IC, LSTTL HEX D TYPE F/F	74LS378
U3	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U4	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U5	991-041090-001	IC, CMOS 8 CHANNEL MUX	4051B
U6	991-045305-001	IC, TTL HEX BUFFER/DRIVER	7417
U7	991-041176-001	IC, DUAL OP AMP	4558
Q1-Q4	991-041052-002	TRANSISTOR, PNP SMALL SIG.	2N3906
Q5	991-045215-001	TRANSISTOR, NPN HI CURRENT	TN2219
(30)	939-045874-001	LED, HIGH BRIGHTNESS	RED
C1	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C2	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C3	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C4	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C5	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
C6	945-044465-003	CAPACITOR, ALUMINUM ELECT.	10 UFD/25V
C7-C33	947-045183-104	CAPACITOR, CERAMIC TUBULAR	.1 UFD
R22	925-045880-001	POT, ROTARY PC MTG LINEAR	10K
R23	925-045881-001	POT, ROTARY 12 TURN LINEAR	10K
R24	925-045880-001	POT, ROTARY PC MTG LINEAR	10K
R25	925-045881-001	POT, ROTARY 12 TURN LINEAR	10K
R26	925-045880-001	POT, ROTARY PC MTG LINEAR	10K
R27-R42	925-045880-001	POT, ROTARY PC MTG LINEAR	10K
R43	925-045880-002	POT, ROTARY PC MTG AUDIO	5K
R44	925-045880-002	POT, ROTARY PC MTG AUDIO	5K

MEMORYMOOG OCTAVE TRANSPOSE BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
(2)	960-045861-001	SWITCH, CONTACT SPRING	
(2)	960-045861-002	SWITCH, CONTACT BUTTON	
(2)	973-041409-036	SPACER	#8 X 7/16"
(2)	975-045466-001	SPRING, COMPRESSION	SWITCH
SW1	964-044082-103	BUTTON, LIGHT GRAY	"-1"
SW2	964-044082-101	BUTTON, LIGHT GRAY	"0"
LED1	939-045874-001	LED, HIGH BRIGHTNESS	RED
LED2	939-045874-001	LED, HIGH BRIGHTNESS	RED
U1	991-042388-001	IC, DUAL VOLTAGE COMPARATOR	LM393

MEMORYMOOG LEFT HAND CONTROLLER PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
	925-040930-003	POT, ROTARY LINEAR	10K MODULATION
	925-040930-003	POT, ROTARY LINEAR	10K PITCH BEND
(1)	962-041179-001	DETENT, TEFLON	PITCH WHEEL
(1)	961-041178-001	DETENT, SPRING	PITCH WHEEL
(2)	967-041185-003	BRACKET, POT L.H. CONTROL	MOD & BEND
(2)	997-041597-002	WHEEL, LEFT HAND GRAY	MOD & BEND

MEMORYMOOG JACK BOARD PARTS LIST

REF DES (QTY)	PART NUMBER	DESCRIPTION	TYPE/USE
P91	910-040299-008	HEADER, CIS .1" CNTRS.	8 PIN
P92	910-040299-005	HEADER, CIS .1" CNTRS.	5 PIN
J1	910-045552-001	JACK, .250" 2 CONDUCTOR	
J2	910-045552-003	JACK, .250" 3 CONDUCTOR N/C	
J3	910-045552-003	JACK, .250" 3 CONDUCTOR N/C	
J4	910-045552-001	JACK, .250" 2 CONDUCTOR	
J5	910-045552-001	JACK, .250" 2 CONDUCTOR	
J6	910-045552-001	JACK, .250" 2 CONDUCTOR	
U1	991-041146-001	IC, DUAL OP AMP	4558
R3	925-042526-004	POT, TRIM CERMET	25K
R6	925-042526-003	POT, TRIM CERMET	10K
S3	910-041451-001	JACK, 3 PIN MALE PANEL MTG	XLR TYPE
J7	910-041306-001	JACK, PHONE MONO 1/4"	
J8	910-041306-001	JACK, PHONE MONO 1/4"	
J9	910-041306-001	JACK, PHONE MONO 1/4"	
J10	910-041306-001	JACK, PHONE MONO 1/4"	
J11	910-041306-002	JACK, PHONE MONO 1/4" N/C	
J12	910-041306-005	JACK, PHONE STEREO 1/4"	INSULATED
J13	910-041306-001	JACK, PHONE MONO 1/4"	
J14	910-041306-001	JACK, PHONE MONO 1/4"	
J15	910-041306-001	JACK, PHONE MONO 1/4"	INSULATED
J16	910-041306-001	JACK, PHONE MONO 1/4"	